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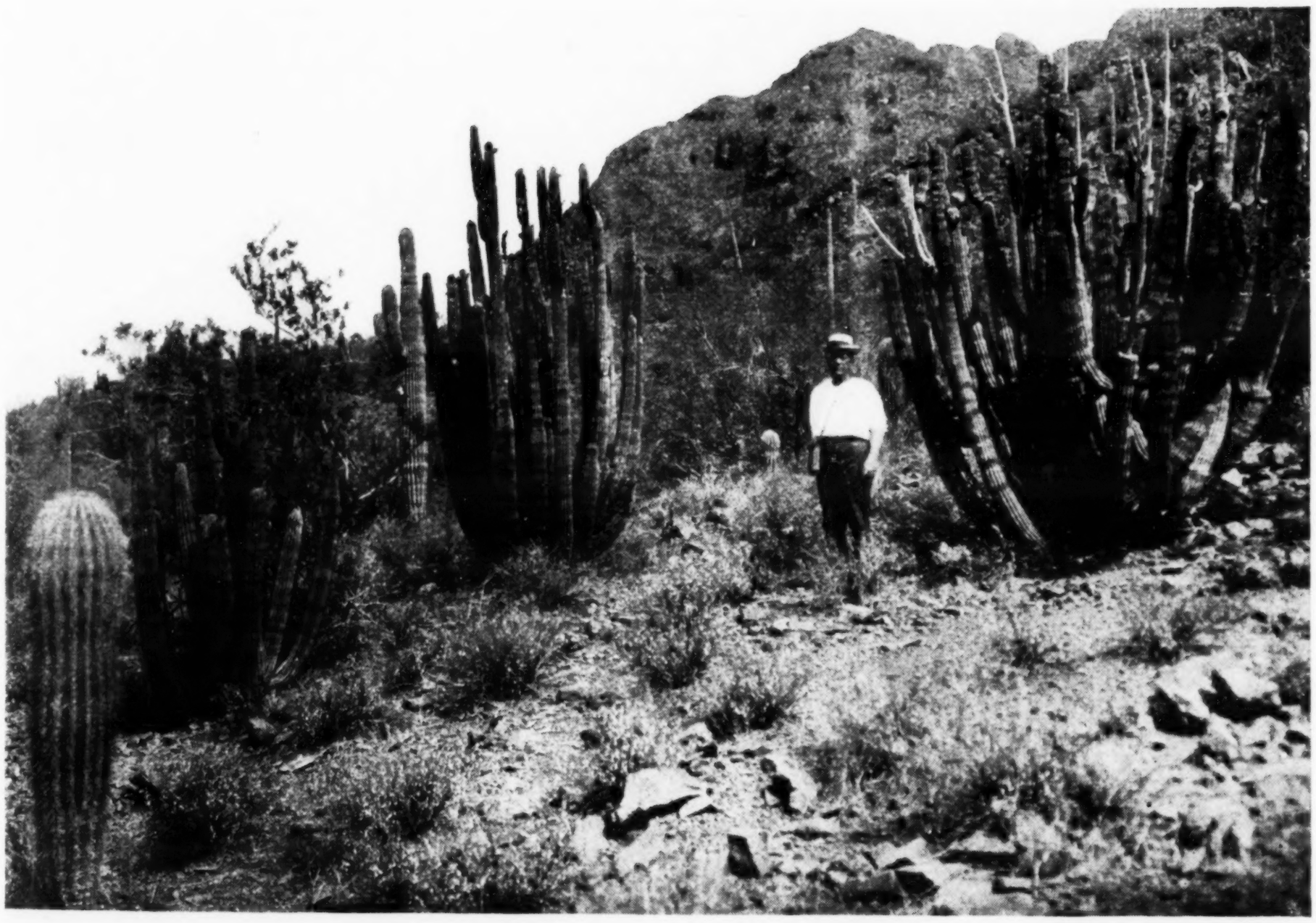

THE ORGAN-PIPE CACTUS—A DESERT FOOD-PLANT

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Inheritance of Artistic Talents

The Herediscope Demonstrated

Birthrates of Graduates and of Pioneers

Combats of Animals

VOLUME 20 SEPTEMBER, 1929 NUMBER 9

The American Genetic Association

An incorporated organization devoted to promoting a knowledge of the laws of heredity and their application to the improvement of plants, animals, and human racial stocks

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THE GIANT CACTUS FURNISHES ITS OWN HARVESTING TOOLS

Frontispiece

Two "ribs" of a dead cactus are spliced together to make a pole long enough to push the fruits off the tops of the tall plants. The fruits are a source of food and drink to the Indians, especially valuable because of the ability of the Sahuaro to resist long periods of excessive drought. The Sahuaro and the Organ-Pipe Cactus are possibly of economic importance in a vast arid area in the Southwest United States, where irrigation water will never be available.

THE GIANT CACTUS OF ARIZONA

The Use of Its Fruit and Other Cactus Fruits by the Indians

FRANK A. THACKERY and A. R. LEDING*
Bureau of Plant Industry, U. S. Dept. of Agriculture

A DESERT FOOD-PLANT
Figure 1

The organ-pipe cactus (*Lemaireocereus thurberi*) is another species whose fruits are used for food. A small Sahuaro (Giant Cactus) in the left foreground and others in the background.

SINCE the explorations of the first white men into the desert regions of what are now southern Arizona and northern Sonora, it has been known that the aboriginal inhabitants made use of the fruits of certain species of cactus as a source of food and drink. From the time of the Spanish conquistadores and friars, who explored this region in the sixteenth century, to the present day, references to this fact may be found in the writings and journals of the travelers. Especially is this true of the tall and stately Giant Cactus or Sahuaro and the uses made of its fruit by the Indians. The extent to which such fruits are used, however, and the high regard in which they are held is not generally known outside of the immediate locality. The fact that the Indians, and particularly the Papagos, cling to the use of these fruits is especially significant in view of the ready availability and easy use of many modern manufactured food products.

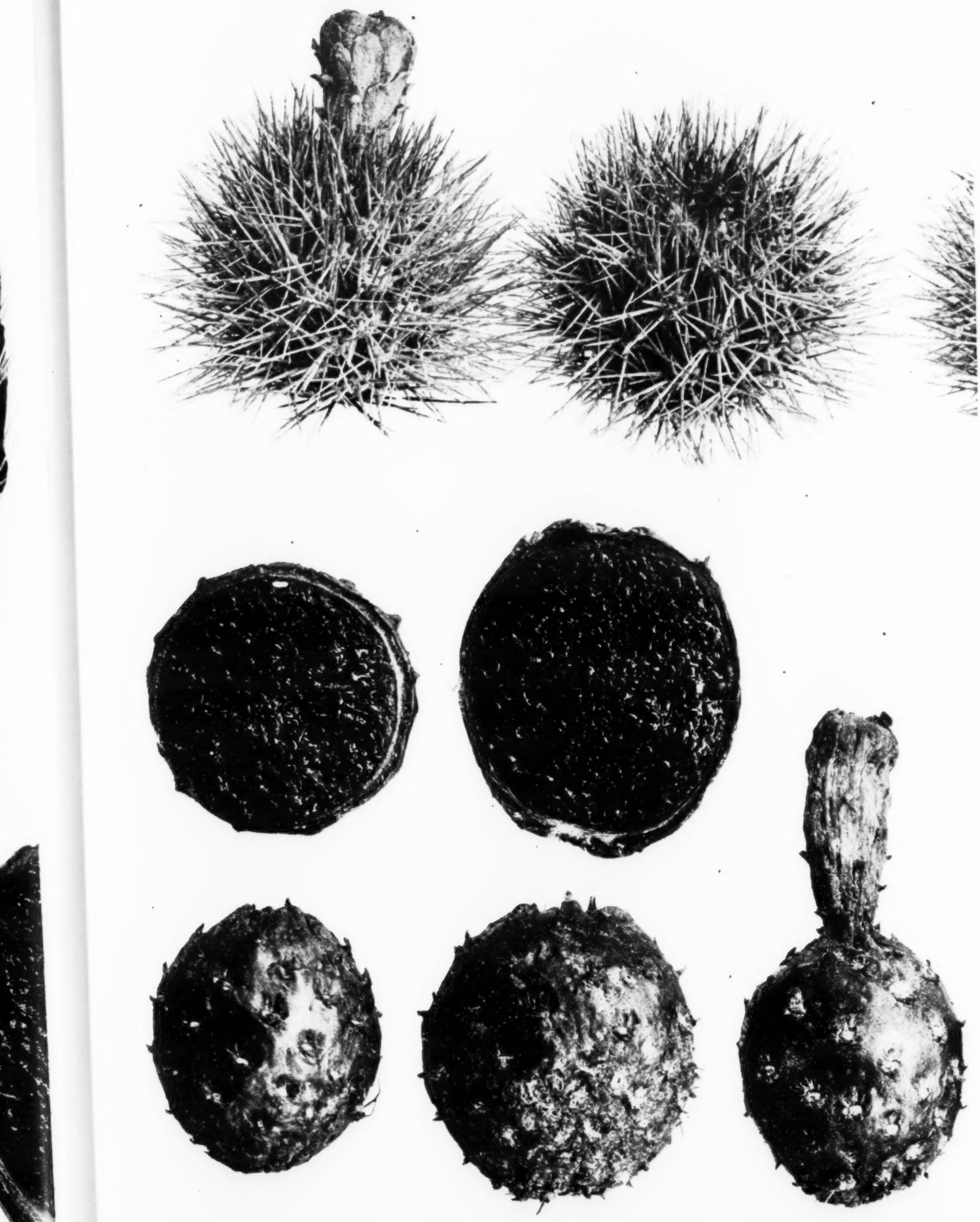
Some of the references in historical works are of much interest. Perhaps the earliest is one quoted by Bancroft, who in his "History of New Mexico and Arizona" states that Juan de Onate,

*The writers are indebted to Dean J. J. Thornber of the Universiyt of Arizona, Tucson, Arizona, and to Robert H. Peebles of Sacaton, Arizona, for valued assistance.

TYPICAL SPECIMENS OF LARGE SAHUARO FRUITS

Figure 2

The half-sections show the range of variation in thickness of rind. The pulp is used for food, the rind being discarded. (Natural size.)



FRUITS OF THE ORGAN-PIPE CACTUS

Figure 3

The unripe fruit with the spines attached and the mature fruit after the spines have fallen. In the center a cross-section and vertical-section of the ripe fruit after the spines have fallen. Note the thin rind as compared with that of the sahuaro fruit in Figure 2. (Natural size.)

conqueror and governor of New Mexico, while on an exploratory journey westward from his headquarters on the Rio Grande in 1604, reported that he at length came to a country where the "tierra caliente began to produce the pitahaya." The word "pitahaya" was used by the Spaniards as a name for several of the tall cacti of Spanish America, together with their fruits, but in this case in all likelihood it referred to the Sahuaro.

Padre Eusebio Francisco Kino, the Jesuit friar, whose explorations from 1687 to 1710 covered southern Arizona as far west as the Colorado River, recorded in his memoirs the use of cactus fruits by the Indians of that time. This great missionary wrote in a letter October 20, 1698, to "My Father Visitor Oracio Polise," reporting upon a visit to the Indians of Sonora, as follows:

> That in all places they received us in houses made ready with crosses and arches erected, giving us many of their plentiful pitajayas, and hares, deer, rabbits, etc., from their hunts, and with much rejoicing, feasts, dances, and songs by day and by night.

Again he says: On the fourteenth of October, (1700) setting out for San Luys Bertrando de Bacapo, after a journey of six leagues there came out to meet us many natives with many of their viands and many very good pitajayas, which on this coast (Gulf of California) are abundant and last until December. After six leagues journey farther we arrived at San Luys Bertrando, where we were welcomed by one hundred fifty persons, with many of their viands and pitajayas, and we spoke the word of God to them all.

Father Kino also says: On the tenth (April, 1701), we rested here at San Xavier, giving various Christian instructions to the many natives who were here. We saw the good field of wheat belonging to the church, the sevénty head of sheep and goats, and the cattle which had remained (for more than two hundred had returned to San Luys on account of the neglect of the few cowboys, especially when they had gone to eat pitajayas).

Among other observations. one that is of particular interest, was made by Dr. J. M. Bigelow, botanist of the United States Government expedition, which in 1853-4 explored a route near the thirty-fifth parallel of latitude for a railroad from the Mississippi River to the Pacific Coast. Among his notes on the flora of the desert Dr. Bigelow says:

> The fruits of many cerei are edible, with something of the flavor and shape of a large gooseberry. They are thickly covered with sharp spines, but as soon as the fruit ripens, these can be brushed off with ease. By peeling the rind there is left a large sweet, delicate pulp that will rival any gooseberry. The top of this Giant Cactus, however, yields a pitahaya, far sweeter and more delicious than those which grow on more humble stems. The Indians collect large quantities of it by tying a fork to the little end of a long willow pole which enables them to reach and bring down the fruit without injuring it. They make a syrup or conserve from the juice which serves them for luxury as well as sustenance, and which can be preserved for a long time. The Mexicans call the tree "suwarrow," the Indians, "harsee," and the syrup manufactured from the juice, "sistor." The juice of the flesh of the tree is quite bitter.

Several years before Dr. Bigelow visited the region, Major W. H. Emory, who led the Advanced Guard of the "Army of the West" from Fort Leavenworth to San Diego, California, during the Mexican War, in his colorful descriptions of the country through which he passed in November, 1846, said:

> At the point where we left the Gila, there stands a cereus six feet in circumference and so high I could not reach half way to the top of it with my sabre. . . . These plants bear a saccharine fruit much prized by the Indians and Mexicans. They are without leaves, the fruit growing to the boughs. The fruit resembles that of the fig only more soft and delicious.

Also in speaking of the Pima Indians appearing at camp for traffic November 11th, 1846, Major Emory says:

> The camp was soon filled with men, women and children, each with a basket of corn, frijoles or meal for traffic. Many had jars or molasses expressed from the fruit of the *Cereus giganteus.*

In the *Diary and Itinerary of Francisco Garces,* translated by Elliott Coues, the noted Catholic missionary recording the drunkenness of the Pima Indians

A SAHUARO "FOREST" IN SOUTHERN ARIZONA

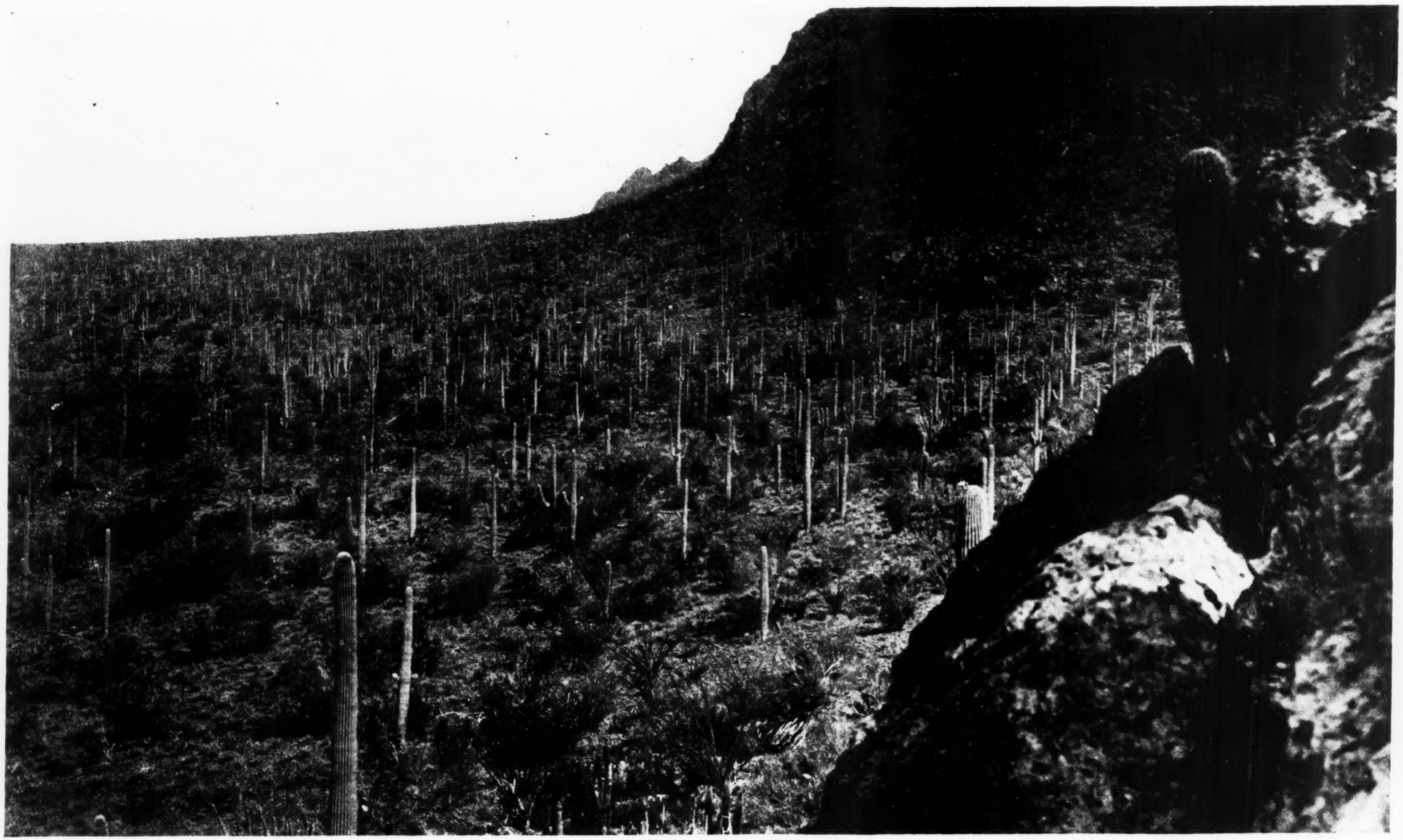
Figure 4

on the occasion of a feast in honor of his arrival at their villages in September, 1776, says:

I arrived at the Pima Gilenos, accompanied by the governor of the Cocomaricopas. There was great rejoicement, for there had spread thus far the report that they (the Moquis) had me killed. The governor of the Pimas told me that all of the relatives were well content and wishing to make a feast, all the pueblos together. I agreed to this, but on condition that it should be apart from me, foreseeing in this what would come to pass. In a little while I heard that they were singing "a heap" (de monton); this was stopped presently, but was followed by a great uproar of discordant voices, and shouting, in which they said, "We are good. We are happy. We know God. We are the fellows to fight Apaches. We are glad the old man (as they call me) has come and not been killed." This extravagant shouting (exorbitante griteria), a thing foreign to the seriousness of the Pimas, I knew came from drinking, which produced various effects. Some came and took me by the hand, saluting me. One said, "I am Padre de Pedro." Another said to me, "Thou hast to baptize a child." Another, "This is thy home, betake not thyself to see the king, nor to Tucson." Others made the sign of the cross, partly in Spanish; so that though I felt very angry at such general drunkenness, there did not fail me some gusto to hear the good expressions into which they burst, even when deprived of reason. The next day I complained of these excesses to the governor, who told me that it only happened a few times and in the season of saguaro, and adding that it made his people vomit yellow and kept them in good health. What most pleased me was to see that no woman got drunk; instead of which I saw many of them leading, by the bridle, the horse upon which her husband was mounted, gathering up at the same time the clothes and beads that the men scattered about, in order that none should be lost.

A Life-Saver of Olden Times

At the present time the Papago Indians of Southern Arizona make a more extensive use of the fruit of the Sahuaro (*Carnegiea gigantea*) than other tribes of the southwest. The importance of this fruit to these people in olden times is indicated by the fact that they began their calendar year at the harvest time, a custom which still persists. The fiesta to celebrate this event is known by them as "Navaita", a Papago word derived from "Navait",



A CACTUS FOREST
Figure 5

View of a heavy growth of Giant cacti at the southern end of the Quijitoa Mountains, southern Arizona. Such "forests" yield a heavy crop of fruit even after three years of extreme drought.

meaning wine, and suggested by the wine-making from the fruit of this cactus. It is very evident, from information procured from the older Papago Indians of today, that in former times the intoxicating drink which was made from the juice of the fruit of the Sahuaro was very generally used in religious supplications for rain, in the firm conviction that without it rain would fail to come. The harvest lasts from late June until the latter part of July or until the summer rains begin. According to the Indians the ripening fruit spoils rapidly after a rain.

At about the same time of year the fruit of another large species, the Organ-pipe cactus (*Lemaireocercus thurberi*) becomes ripe and is also gathered by the Indians. It is somewhat similar to the fruit of the Sahuaro, but smaller in size and covered with many more sharp spines while in the unripe state. Other cacti, particularly several species of Opuntia, ripen their fruit from this time until the latter part of summer and are utilized to a limited extent. The fruit of the Sahuaro is, however, by far the most important as a source of food to the Indians of southern Arizona, by reason of its proximity, abundance, and comparatively high sugar content.

From an intimate acquaintance of many years with the Papago Indians, it is easy to understand why they should still show such marked respect for this "sentinel of the desert", the Sahuaro. There is little doubt that it has frequently been a life-saver to their ancestors by providing an abundance of fruit for syrup and preserves, and seed for a nutritious meal-cake, when all other sources of food failed during extended drought periods so common to the arid southwest. One of the writers has witnessed these Indians on several occasions in recent years who, when clearing away brush for the construction of roads, would frequently curve the road for the sole purpose of saving one or more of the Sahuaros.

The remarkable habit of the Sahuaro of maintaining a comparatively bountiful supply of moisture enables the plant to produce a good crop of fruit each season with evident disregard of extended drought periods. The writers have witnessed a good crop of the fruit in southern Arizona after an unusually dry three-year period. To this fact is due their great importance as a dependable source of food. This storage capacity and drought-resistant tendency appears more definite in the Sahuaro than in the Organ-pipe cactus.

The Sahuaro is widely distributed over the state of Arizona extending well up into the central portion of the state, north of the Gila River. It finds its most congenial surroundings, however, and attains its most perfect development and greatest abundance in the southern part of the state near the Mexican border, where in some places, particularly in the lower mountains and along the bases of the higher mountains it is so abundant as to form veritable forests. The plants cling to the higher and warmer localities and are seldom found in the floor of the valleys.

The Organ-pipe cactus, or "pitahaya", as the Papagos distinguish it from the sahuaro, seems to be even more particular in its requirements and, in southern Arizona, is rarely found excepting on the warmer slopes of the lower and more southerly mountains. Consequently this species does not appear in such great numbers as the Sahuaro and there are no extensive "forests" of the plant. However, it is very plentiful in parts of the state of Sonora, Mexico, and the Indians prefer its fruit to that of the Sahuaro. A considerable number of the older Papagos still travel long distances in order to obtain this choicer fruit.

View of a heavy growth of Giant cacti at the crop of fruit even after three years of extreme drought.

Other Edible Cacti

In addition to these two, several smaller members of the Cereus family

A SAHUARO HARVEST CAMP

Figure 6

Note the pulp being strained into large baskets in the foreground.

occur, the most important of which is the "Viznaga" or "Niggerhead" cactus (*Ferocactus wislizeni*). These plants sometimes reach a height of three feet or even more, although they are usually smaller. They bear numerous yellow, waxy-fleshed fruits, about an inch and a half to two inches long and about half as broad, which are filled with many small, black seeds. This is the famous "barrel" cactus, which upon occasion has afforded a supply of liquid to the thirsty desert traveler. As prepared and used by the Indians for food, the fruitpods are cut up and cooked with cornmeal or other material, the seeds being discarded. The Opuntia family, of which several species are indigenous, is ever present, growing under widely differing conditions and appearing to be not nearly so particular as to habitat as the Sahuaro or Organ-pipe.

A striking feature of the desert landscape at any time, the giant cactus is especially attractive during the blossoming season, when it is surmounted by a crown of large, white-petaled flowers. The flowers usually begin to bloom during the latter part of May and continue to appear during June. The fruits ripen about a month later. Several flowers which appeared in June, 1924, at Sacaton, Arizona, were kept under observation and it was found that the period for the development and ripening of the fruit averaged thirty days. The fruits vary much in size, shape, abundance of spines, thickness of rind and juiciness. They vary in diameter from less than an inch to nearly two inches, and in length from two to three and one-half inches. Some are egg-shaped while others are slender and tapering. Some bear several spines at each areole while others are entirely without them. The spines are never very troublesome, however, and may be easily removed. In the relation of thickness of rind to juiciness,

A SAHUARO IN FLOWER

Figure 7

A young Sahuaro near the close of the flowering season. The flowers appear during May and June. The fruit ripens about a month later.

Sahuaro fruits bear some resemblance to oranges; the thin-skinned ones usually being full of rich, juicy pulp while those with a rind a quarter-inch or more in thickness are often relatively dry. The unripe fruit is usually light green in color, changing to a beautiful red, sometimes streaked with yellow when fully ripe. The pulp is white in the green state, but changes to a rich, deep red when ripe. The seeds are small, being about the size of turnip seed, and are white at first, changing to shiny black in the ripe fruit. The seed of both the Sahuaro and the Organ-pipe are quite oily and nutritious, and, in the past, were important to the Indians as a source of food. They may now be purchased at some of the local markets, but their present value is mainly for chicken feed for which they are very good.

Harvest Camps

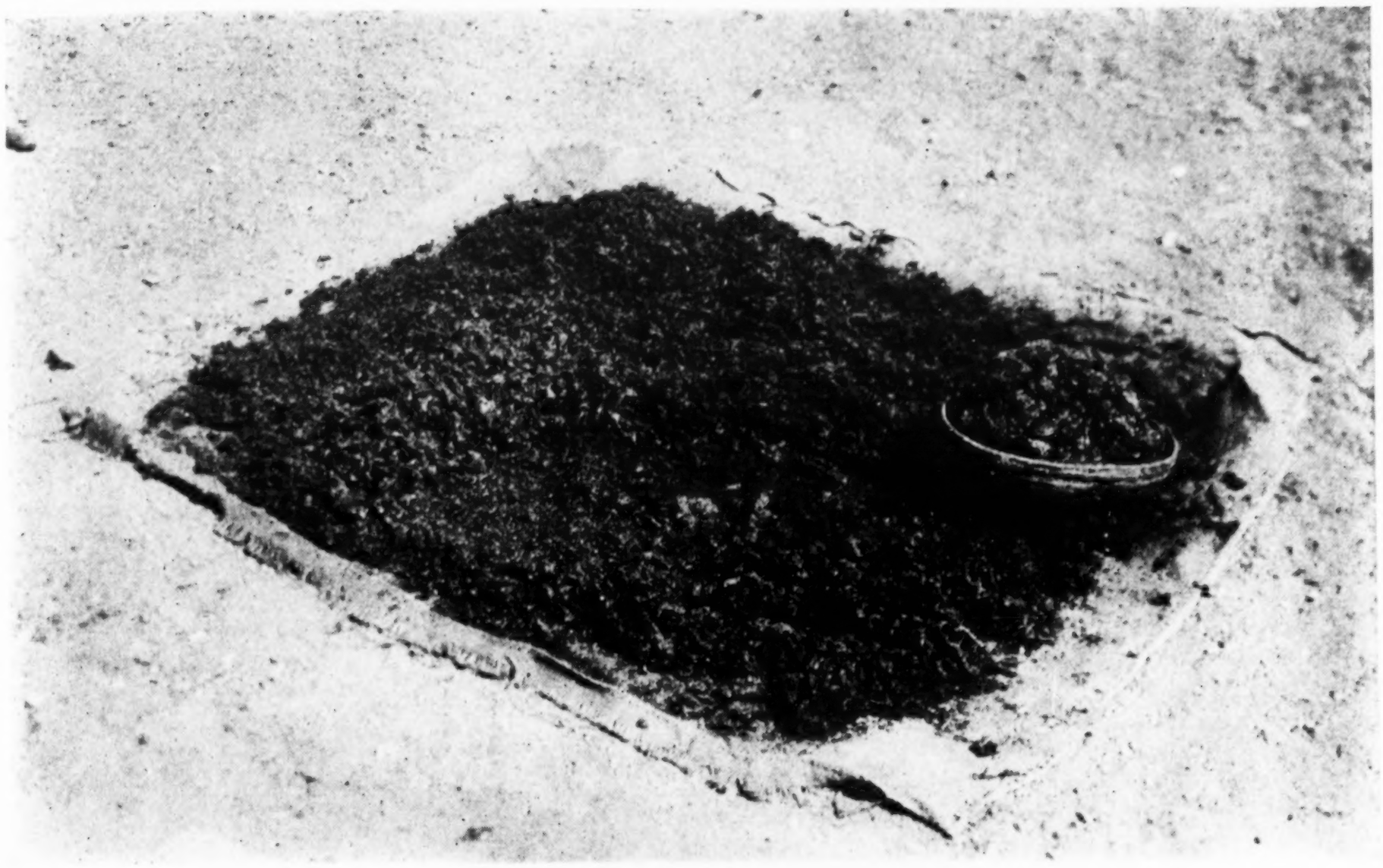
In the localities of southern Arizona where Sahuaros are plentiful, the Papago Indians still have many camping places which are used year after year and are usually equipped with one or more brush houses or shelters. When harvest time comes the Indians move from their homes to these camps, taking with them a part of their household goods. These camps are looked upon as common property, as are also the Sahuaro "forests". The camps are usually continuously occupied during the harvest season as one family after another prepares the quantity of fruit it desires and then returns home.

Several families may go to the harvest together, but they usually separate to camp and gather the fruit. As a rule a family does not move from one camp to another, but rather, first selects a locality where the fruit is plentiful enough for its requirements. If the Sahuaro harvest should come at the same time as the wheat harvest, the latter being much more dependent upon the spring and early summer rains, the family is divided, part going to the Sahuaro camp and part remaining at the home or rancheria to harvest the

GATHERING THE FRUIT

Figure 8

The skin is slit with the thumb-nail, and the pulp is turned into a basket. Some six hundred Papago families gather in the neighborhood of 100,000 pounds of these fruits every year, and much more goes to waste.



SUN DRYING OF THE PULP
Figure 9

Pulp of Sahuaro fruit being dried in the sun. The dried pulp will keep indefinitely, and is cooked up as needed to make syrup.

wheat. The wheat comes first in importance, however, and in case of necessity the Sahuaro harvest is foregone, but it seldom happens that both harvests may not be accomplished.

Not so many of the Indians gather the fruit now as in former days, but those who, through inclination or force of circumstance, do not go to the harvest may purchase the syrup and other cactus fruit products from those who do. In fact, a demand for these products, especially the syrup, is recognized and frequently more is made than for family requirements with the purpose of sale in view. The Papago or Pima Indian who has not been able to make the syrup for his family needs does not hesitate to pay as much as fifty cents per quart for it.

From three to ten gallons of syrup and a smaller quantity of preserve is put up by the average family. The seed stored for meal-cake or for chicken feed or sale is simply the amount extracted from the pulp consumed in making the syrup. When it is estimated that twenty-five to thirty pounds of fruit are required to make one gallon of syrup and that at least one-half of the twelve hundred Papago families gather the fruit, it will readily be seen that a very large quantity is utilized. However, tons of the nutritious fruit go to waste each season. Much of it is also consumed in the fresh state, and sometimes the pulp is sun-dried just as it comes from the fruit-pods, being later pressed into solid masses to be stored for future use. When prepared in this manner and stored for a time, it is said by the Indians to make better flavored syrup. After being thus sun-dried the pulp is said to keep indefinitely.

The fruit is usually gathered in the early morning hours, and principally by the women. The rôle of the men seems to be to care for the stock and to keep the camp supplied with wood and water. It is sometimes necessary to haul the water ten or fifteen miles.

Harvesting the Fruit

The Sahuaro does not, as a rule, bear fruit to any considerable extent until it has grown to a height of ten to fifteen feet. The Indian has utilized the plant itself to serve his needs in providing a means of reaching the fruit. Two of the slender ribs from a dead sahuaro are spliced together to make a pole which is long enough to reach the fruit on any save a very few of the tallest plants. These poles vary from fifteen to twenty-four feet in length. Short pieces of wood fashioned from branches of creosote bush (*Covillea tridentata*) or the catclaw (*Acacia greggii*) fastened across the poles at an oblique angle form a sort of double hook which may be used either to pull down on the fruit or to push upward against it. Each pole is furnished with two of these cross pieces, one at the top and one near the middle, the latter being more convenient and practical for reaching the fruit which is nearer the ground.

A very slight push or pull is usually sufficient to dislodge the fruit, which then falls to the ground, no attempt being made to catch it. Except for an occasional very ripe one which may split, the fruit is not injured by the fall. Only fruits which show the red coloring of ripeness are picked, there being ordinarily from one to six ready at a time on each plant. The picking and gathering is slow work, and it requires most of a morning to secure a basket full. A single plant of the Sahuaro may bear as many as two hundred and fifty fruits in a season, although smaller numbers are much more common. All of the ripe fruits on a number of adjacent plants are knocked to the ground before any are picked up. The pole is then laid aside and the fruits are gathered. As each is picked up the skin is deftly slit with the thumb-nail, turned inside out and the pulp dropped into the basket. As a rule only one large basket full (equal to approximately fourteen quarts) is gathered in one morning, the balance of the day being spent in preparing and cooking the material. If there is need for hurry an additional basket of pulp may be gathered in the afternoon and cooked in the evening.

Upon returning to camp with the basket full of pulp, it is placed in a large olla or earthen water jar of native manufacture. A small quantity of water is added and the cooking begun. After cooking for a half-hour the juice is well separated from the seeds and pulp, and it is then strained into another olla. Ordinary screen wire is used as a strainer, and being rather coarse for the purpose it permits a portion of the seed and pulp to pass through with the syrup. In the old days the Papagos made a strainer by weaving together the long leaves of the Sotol plant (*Dasylirion wheeleri*) and doubtless it served the purpose better than its modern substitute. Most of the syrup prepared nowadays contains more or less of the seed and pulp, to which the Indian does not seem to object.

After the cooked pulp has been thoroughly drained, the juice is returned to the fire and is allowed to cook slowly for about an hour, by which time it has become quite syrupy, and is then ready for consumption or storage. A small amount of preserve is sometimes made, this being merely the unstrained pulp cooked to the desired consistency, but by far the greater part of the fruit is made into syrup. The portion to be kept for future use is placed in ollas and sealed tight, the seal being accomplished with a piece of broken pottery chipped into a circular form to fit the mouth of the olla. This crudely constructed cover is held in place by a preparation either of adobe mud mixed with fine grass or a transparent yellowish brown gum or lac gathered from the "Samo prieto" (*Coursetia glandulosa*) upon which it is produced by a scale insect (*Tachardiella fulgens*). When properly put up in this manner the syrup or preserve will keep more than a year.

A GIANT OF THE GIANTS
Figure 10
A fine specimen of Sahuaro in fruit in southern Arizona. Its height was about thirty feet.

The quality of the product varies considerably, some of the Indians preparing a much more palatable syrup or preserve than others. In many cases the syrup appears to be over-cooked from the standpoint of the white man's taste and may have a pronounced flavor of burnt sugar. However, the careful and experienced Papago syrup maker prepares a product of excellent and attractive quality which closely resembles in color and taste a good grade of our own sorghum molasses, though the best Papago syrup is much thinner. The best of the Papago sahuaro syrup is very wholesome and palatable and adds much to the attractiveness of the morning hot-cakes.

The sun-dried pulp, when properly prepared, will keep from one season until the next. It is sometimes eaten dry or it may be moistened with water. Upon occasion a batch of syrup may be prepared from it, for which purpose as stated, it is said to be superior to the fresh fruit. The dried seed is sometimes ground up and used, but most of it serves as chicken feed.

The Pima Indians, living in the Gila River valley in Arizona, do not make such extensive use of the fruit of the Sahuaro as their Papago relatives and neighbors to the south. Contact with the white man and proximity to trading posts, where modern canned foods and baker's bread may readily be obtained, have induced changes in the life and food habits of these people. But among the older Indians there are still some who cling to the old-time foods, at least as a means of "helping out".

Use of Cactus Flowers

In the spring, following unusually rainy winters, all of the desert vegetation attains a vigorous growth. In such seasons some of the older Indian women still take advantage of the opportunity to gather the flower buds of two species of the Opuntias (*Opuntia versicolor* and *Opuntia echinocarpa*). These plants are quite plentiful and a generous supply of the buds may be gathered without going far afield.

These buds are quite spiny, a characteristic expressed in the botanical name of one of the two species, and may not be handled until the spines have been at least partially removed. They are picked from the plants with a pair of small sticks held in one hand somewhat after the fashion of Chinese chopsticks, the Indian women being quite adept in their use. Most of the spines are removed by rolling the buds on the ground and rubbing them with a bunch of grass.

One of the writers witnessed the preparation of this food material in the spring of 1926 at Sacaton, Arizona. This was following a winter of unusually heavy rainfall and was the first time in several years that the flower buds had been sufficiently plentiful to be gathered. Several large baskets, dishpans and tubs had been filled with the buds, for this was a cooperative enterprise of two neighboring Pima families. In a shallow hole in the ground, three or four feet in diameter, a bed of mesquite-wood coals was prepared and then covered with a layer of stones. Upon the stones a thick layer of the young growth of the ink-weed (*Dondia nigra*) was placed. The flower buds of the cactus were spread in a large rounding pile upon this layer of ink-weed and covered with a second layer of the same weed. The entire pile was then banked with earth to a depth of several inches. The cooking process usually lasts overnight and sometimes is repeated. Upon final removal from the fire the buds have a shriveled and darkened appearance, are quite tender, and the remaining spines are much softened. The preparation of the material is completed by drying in the sun, after which it will keep indefinitely. The buds are used as a sort of vegetable stew mixed with "greens" of an annual salt-bush (*Atriplex wrightii*) or "lambs quarter" (*Chenopodium album*). Sometimes they are ground up and are used to thicken meat broth or stew, or they may be used as a sort of relish or pickle. It is a time-honored food of the older Indians and many of the younger generation confess a fondness for it.

But, after all, the fruit of the Sahuaro has been one of the most important and dependable sources of food to the Indians of the Southwest, and it is possible that their discovery and continued use of it may yet result in adding another commercially valuable food product to the already creditable list known to have been originated by the North American Indian. Should the fruit of the friendly Sahuaro prove commercially of value it would aid materially in the reclamation or better utilization of a vast area of our Southwestern arid land for which we may never have irrigation water.

Other Literature On the Giant Cactus

LUMHOLTZ, CARL. 1912. New Trails in Mexico, Charles Scribner's Sons, New York.

HORNADAY, WM. T. 1908. Camp Fires on Desert and Lava, Charles Scribner's Sons, New York.

STANDLEY, PAUL C. Trees and Shrubs of Mexico, *Contributions from the U. S. National Herbarium*, Vol. 23, Part 4.

BRITTON, N. L. and J. N. ROSE. The Cactaceae, Vol. 2, Carnegie Institution of Washington, No. 248.

Cactus in Madagascar

Writing in *Science* (July 12, 1929), C. F. Swingle calls attention to the interesting history of the prickley pear (*Opuntia dilleni* and O. *fucus-indica*) introduced into Madagascar about two centuries ago. The plants throve in the more fertile regions and became a pest. In the arid parts of the island they became the most important economic plant, furnishing not only food and drink for man and beast, but impenetrable barricades around fields and villages. Unfortunately, cochineal insects were recently introduced, and they have exterminated the cacti, a serious calamity to the Antandroy tribe. An effort is being made to use cochineal-resistant species to replace the susceptible species that have been eradicated.

THE INHERITANCE OF ARTISTIC TALENTS

PAUL POPENOE
Pasadena, California.

THAT musical capacity is inborn is widely believed and seems to be supported by the evidence. Johann Sebastian Bach was passionately devoted to music by the age of ten, and is supposed to have composed several fugues before fifteen, although his first extant work does not date much earlier than eighteen.

Ludwig van Beethoven's "one interest from his earliest youth seems to have been music." He gave his first public concert at seven; his first composition was written at ten. Some of the compositions of his thirteenth year have been published.

Georges Bizet entered the conservatory of Paris at nine.

Johannes Brahms devoted so much of his time to original composition between his tenth and twelfth years that his piano teacher began to complain. He said that he had invented a system of musical notation for his own use before he was old enough to know that such a thing already existed.

Franz Chopin is said to have produced pieces for the piano as early as eight; at the age of 20, when most boys are in the rah-rah stage, he was already a perfectly matured musician.

Claude-Achille Debussy entered the Conservatory at eleven.

César Franck appeared as a virtuoso at eleven.

Charles Gounod, who declared that he drank as much music as milk from his mother's breast, said he had a clear and precise idea of the difference between the major and minor modes before he was old enough to talk plainly.

Christopher Willibald Gluck, brought up in the woods by his father, who was a sort of forest ranger, knew nothing of music until he went to school at twelve. It immediately took hold of him, until at eighteen he had resolved that "a musician he would be and nothing else."

George Frederick Handel was destined by his father to be a lawyer, and all his early musical interests were discouraged violently. Nevertheless, "his earliest delight was a mimic orchestra", he was composing good trios at ten, and had turned out a successful opera at twenty.

Franz Josef Haydn showed marked musical talent while still in the kindergarten period, and was beginning to compose at six. From eight to eighteen he worked mostly on music while the other boys were at their games, and by twenty-four he was a fully recognized genius.

Josef Hoffman was, in 1883, concert pianist and composer at the age of seven.

Jakob Ludwig Felix Mendelssohn-Bartholdy, one of the ideal child prodigies of history, played the piano with extraordinary ability even in his eighth year, and in his eleventh and twelfth years wrote 50 or 60 complete movements. His sister Fanny was quite his equal as a performer, though she did not display the same creative talent.*

A Contemporary Prodigy

Yehudi Menuhin is said to have shown "musical consciousness" at twelve months, when he first attended

*The lack of creative talent among women stands out nowhere more prominently than in the arts, which have in most ages been their special domain. For every man who has studied music or painting during the last thousand years, probably a dozen women have studied it, yet there is in none of the arts (with the exception of the histrionic art) a woman who will rank among the first 10 or 15 men. Even the great cooks and dressmakers have been men.

a symphony. After he began to take lessons, at four years and ten months, "every lesson was a month's progress". He had ten concertos at his command when he appeared as a soloist with the New York Symphony Orchestra at the age of ten, and when W. J. Henderson wrote that he "played in a manner disclosing prodigious command of the violin and a genuinely musical temperament."

Giacomo Meyerbeer, a famous pianist at nine, was composing before the age of ten.

Wolfgang Amadeus Mozart found his sole absorbing interest from childhood in music. His first pieces are said to have been composed at five, when they were written down by his father. Two years later appeared his first published work, four sonatas. "A series of minuets, dating from his sixth year, are distinguished by the formal purity of their style, simplicity, and clearness of melody." In the year 1764, when he was eight, he had already produced six sonatas for the piano and violin and three symphonies for small orchestra. At twelve his first operetta was performed.

Edwin Nyiregyhazi, whose early development has been studied more fully than that of any other child prodigy in the history of music, was not one year old when he tried to imitate singing. In his second year he was able correctly to reproduce melodies sung to him, when he was still unable to talk plainly. (Handel also sang before he could speak.) At the end of his third year it was found that he had the gift of absolute pitch, which neither of his parents possessed, though they were both musicians. At this period he reproduced exactly, on the mouth-organ, any tune he heard; within a few months he transferred this ability to the piano, and at three and one-half years was composing original melodies with accompaniment. He played his own compositions in public in his fifth year; up to that time he had received no lessons in music, but had picked up everything for himself. In his sixth year he began to turn out his first written pieces such as a barcarole, a berceuse, a dance of elves, a wedding march, a funeral march for 'cello, and a serenata.

Gioachino Antonio Rossini played and sang in public by the age of twelve and was directing at fifteen. His first opera was produced when he was eighteen.

Camille Saint-Saens named the notes at 30 months, and a few months later finished in 60 days a standard piano course. At ten he gave his first public concert.

Franz Schubert is said to have written quite a number of songs and pieces for the piano before his tenth year. His rapid advance as a composer and his enormous productivity are matched only by Mendelssohn. In his eighteenth year (1815) he composed a number of works for the stage, masses, sonatas for the piano, and about 170 songs.

Alexander Scriabin extemporized on the piano at five, although he did not write any compositions until eight. A single hearing of a piece at a concert was sufficient to enable him to sit down at his own piano and reproduce it exactly.

Richard Strauss commenced composing at the age of six.

Karl Maria von Weber found his only absorbing interest in music from early childhood, published his first composition at eleven, and wrote the music for a successful opera at thirteen. He has the distinction of furnishing the air ("America") which four countries—Germany, Austria, England, and the United States—have adopted for a national song.

Efrem Zimbalist was first violin and soloist in an orchestra at eight.

Any music lover can extend the list indefinitely from his own knowledge. The brief summary I have given, including almost every type of musical talent, is sufficient to show that the popular belief is well founded. Mu-

sicians, even more than poets, are born, not made.

Intelligence Is Earlier

No other form of special talent in the entire range of human achievement can show such a record of early appearance of genius as does music, although general intelligence is perhaps a little earlier. The future painter, poet, or sculptor has some need for seeing, for reflecting, for understanding the world of nature, before he can show himself to be a supreme artist. The musician has everything in himself. He has no need for prolonged study of the world outside; he merely calls on his own inner resources, and up to a certain point these suffice him.

Looking at the matter a little differently, one must recognize that music is essentially a primitive art.[17]

Indisputably, the greatest attainment in creative music is impossible to one lacking intelligence; yet many savages have a great deal of musical feeling, and could probably be educated to perform modern music acceptably. The musicality of the Negro race is appreciated fully in America.

The inborn capacity of the cave man for music was possibly as great as that of modern man; for this capacity depends upon the ear, in the first place, and there is no evidence that the fineness of the senses has increased during the historic period. Nor has modern man any more intelligence than, say, the Athenians, who possessed no harmony and admired choral singing in octaves which nowadays would not be thought worthy of the kindergarten. The emotional equipment of modern music lovers is apparently not superior to that of the Arabs, whose literature records many instances of persons who fainted, or even died, on hearing a song.[4] Clearly, the modern musician with an orchestra at his command achieves more than does the painted cannibal with his tom-tom, because he has the advantage of the development of the art through many generations, and of tradition which allows him to profit by the gains of the past.

In other words, musical expression and musical appreciation are a normal part of the human race. This does not mean that capacities in either respect are equal, but it does mean that the average would be much higher than at present, if education were conducted differently. Proper education probably would not increase materially the number of Bachs, Mozarts, and Haydns, but it would increase immensely the number of those capable of understanding and enjoying the works of such masters.

Great Geniuses of History

If the fundamentals of musical talent are primitive accomplishments, what is it that makes a great musician? Some light is thrown on this question by a study[1] of the traits of eleven musical geniuses in comparison with some 300 men eminent in other walks of life.

The musical geniuses (Bach, Beethoven, Gluck, Handel, Haydn, Mendelssohn, Mozart, Palestrina, Rossini, Wagner, and Weber) in this particular study show a high average intelligence (IQ at least 160), but they rate somewhat lower than do other great men on intellectual activity, the intellectual-social traits, and physical activity, and relatively higher on the intellectual-emotional traits. The directions in which they particularly excel other great men are esthetic feeling, the desire to excel, belief in their own powers, originality of ideas, extent of mental work bestowed upon pleasures, working toward a distant goal, persistence in the face of obstacles, quiet determination, and a tendency to rate their own abilities correctly.

The possession of these qualities, together with the necessary fundamental capacities, will not automatically produce a musical genius; but it is difficult for a man or woman to become a musical genius without possessing most of them.

A study of the geniuses in the list

I have given at the beginning of this paper, and still more a study of the more ordinary manifestations of musical talent, show clearly that, in general, ability in performance appears earlier than creative ability. This is to be expected. There are, indeed, thousands of competent performers for every one who shows really original creative power.

The facts that music runs in families and that great musicians are concentrated in related groups suggest the importance of heredity but do not prove it, for the same result might occur if musicality were due to training.*

More careful studies of family histories show that the results of various types of mating are about what would be expected if musicality is indeed inherited.[3,5,14]

What Is Musicality?

Such evidence strengthens the case, but still does not make it perfect, for the primary question, whether a given individual in the ancestry is or is not "musical", depends merely on someone's opinion, and no two persons, giving information on this point, will have the same standards of judgment.

Abe Martin observes (and I have been able to verify the statement in my own household) that in every large family there is always one child young enough to enjoy his father's singing. Is this child to be considered the most musical one of the family? If not, just what does "musical" mean?

"Musicality, primarily, denotes the ability to enjoy music esthetically", says one writer. "Further, every degree of profound understanding of musical form and the structure of musical composition is based on musicality. A musical person has a fine and developed instinct for the style and the rigid order of a musical sequence of ideas. Another necessary characteristic of a musical person is his capacity for becoming absorbed in the emotions expressed by music and his ability to enter into so intimate a relation with it, that the whole organization of his soul is affected. The possession of all these qualities results in a capacity for enjoyment which makes music part of the listener's very life, and gives him the power to judge and appreciate musical works of art according to their true value."[10]

Very good; but very difficult to apply in a study of inheritance. For practical purposes it is necessary to break up this "fundamental entity" into more convenient parts. This has been done with notable success by C. E. Seashore[11,12,13] and his own studies of the various elementary traits, together with similar studies by his students and others, bear out the expectations.

Pitch Discrimination

Pitch may be taken as an illustration.[2,7,11,14] There are about 35 d. v. (double vibrations per second) between one note and the next—say A and B—of the standard scale.

Pupils who have a sufficiently fine ear to recognize a difference of two vibrations or less are capable, in this respect, of becoming good musicians. Those whose discrimination lies between three and eight vibrations (and this includes the geat majority of people) have a sufficiently accurate discrimination for the customary musical instruction and enjoyment, but such a one is not likely to become a great violinist, although a famous American singer was found to have a pitch discrimination of only 6 d. v. Pupils whose score lies between 9 and 17 vibrations should not be given any musical instruction unless they particularly desire it, and they might well be excused from class singing in the schools. The child whose discrimination is 18 or above should probably not be encouraged to have anything to do with music, for it would be time wasted. He is tone-deaf.

Ludwig van Beethoven, it is true, was physically deaf in adult life: but he was not born that way.†

Determination of pitch, that is, the ability to name a given note when it is sounded, is of course a different

thing from discrimination. It is a good parlor trick. In many cases it appears that the note is identified by its timbre quite as much as by its pitch. Memory for pitch is still another thing —W. A. Mozart possessed it to an unusual degree. He once remarked, when he began to play his own violin. that it was tuned one-half of a quarter tone higher than the instrument he had played two days before.

Part Singing

And so one might continue to analyze "musicality" through all the characteristics of the sound wave.

Those who do not care for scientific accuracy may find the ability to carry harmony ("sing a part"), still more the ability to improvise harmony, a good practical test of musicality. It has been shown[8] to be not at all associated with ability to perform on the mouth organ or Jews' harp! It is also very little associated with a sense of or feeling for rhythm. This last feeling is a fundamental one, and the reason for its relative lack in some persons—whether due to birth or to education—is still uncertain. The fundamental rhythm is a two-point one, supposed to be based on the fact that the two sides of the body are alike; multiples of it, as four and six, are fairly common. A three-point (waltz) rhythm is also common enough, but its origin a little difficult to explain on the same basis. Five and seven-point rhythms are virtually unknown to man; the starfish might be expected to possess the former, if it depends on the arrangement of the body. With sufficient effort, however, it appears that most persons can be trained to feel a five or a seven-point rhythm.

While much work remains to be done on the inheritance of musical capacity, the general situation is clear.[9] Musicality must be regarded as inborn, and in general it is inborn because it existed in the ancestry. There is little encouragement for an attempt to make a child musical if his ancestry was not musical, or at least, if the ancestry did not have the necessary capacity which would have made it musical in proper surroundings. Whether a child is or is not qualified to profit by musical instruction can be determined easily enough by standard tests. As these tests, given to all the children in many schools, have disclosed the fact that the untalented are now being given musical education in quite as large proportion as the talented, it is evident that there is a great waste of energy, time, and money. A due regard for the facts of heredity will put a stop to this—will release from the piano stool thousands of children who are now drudging away at their forearm and finger movements without the slightest prospect of ever being able to convert them into anything more than forearm and finger movements; and will at the same time discover plenty of undeveloped talent, from which may be made real musicians.

Ability In Drawing

One of Ben Trovato's stories relates to Anthony Van Dyck who, while a school boy, was concerned that a chum was to be flogged. Anthony at once painted the portrait of the master on the seat of his comrade's breeches. The teacher, preparing for action, suddenly realized the undesirability of laying the switch on his own countenance, and the boy escaped punishment.

The jest at least calls attention to

*See Literature Citations 1, 2, 3, 7, 8, 10, 14, 15, 16.

†From the psychoanalytic side, it is urged that musicality may be a compensation for some kind of inferiority, and Alfred Adler points out, specifically, that L. Van Beethoven and W. A. Mozart both had deformed outer ears. The inference is that, feeling themselves inferior for this reason, they worked with great assiduity to show their superiority in something else, namely, music. Assuming for the sake of argument that explanation is valid, it does not dispose of heredity. If a man, for any reason, works with great assiduity and success on his music, the underlying reason may be that he had particular talents along that line. Otherwise he might just as well have worked at something else. Hence the psychoanalytic explanation, far from conflicting with the inheritance of talent, really supports it.

the precocity of artists, and Van Dyck himself was unquestionably painting portraits by the age of fourteen, for one of that period is extant. At sixteen he was maintaining himself independently, and with a degree of recognized success, as was Bartolomé Murillo. Antonio Canova produced two of his great figures, Orpheus and Eurydice, at sixteen. Raphael Sanzio, descendant of eight generations of painters, was helping his father with frescoes at ten or eleven, was executing commissions at seventeen, produced his first famous work, "The Marriage of the Virgin", at twenty-one, and had turned out many of his great masterpieces when he became architect of St. Peter's at 31. Michaelangelo Buonarroti was receiving a regular salary at thirteen for his handiwork. And so the list might be extended indefinitely, as is the case with musicians, down to the child Giotto di Bondone, surprised at his drawing by Giovanni Cimabue, who became his teacher, according to the legend. The early development of talent for the pictorial arts points strongly to the fact that it depends largely on inborn qualities.

This does not minify the necessity for a cultural background for high achievement, nor does it imply that strength of mental imagery, concept of spatial relations, motor coördination with visual impressions, color sense, and the like spring full-grown like Venus from the waves. Prior to the age of ten, for instance, it is only a rare child that shows any conception of three dimensions. But if the rudiments are there, they will grow under normal conditions.

Art and Intelligence

That artistic capacity is not merely a phase of general intelligence was illustrated strikingly when California was being canvassed to find 1,000 extraordinarily bright children for study. In Los Angeles a special class is established for 50 particularly promising pupils in art, who are given individual instruction twice a week by the best teachers the public schools can furnish. This class was naturally scrutinized to find pupils with high IQ, and the supervisors named six boys and nine girls whom they considered most promising, but intelligence tests showed them to have an average of only 109 the highest being 133 and one as low as 79 IQ. Whatever their promise in art, then, which led them to be singled out, after prolonged observation, from a school population of more than 200,000 children, they were in respect of abstract intellect a quite mediocre group.[15]

Essentials of visual art are that the child should possess in a greater degree than ordinary a knowledge of color, of dark and light, of line, of perspective, of subject matter, and of practical application. If the morons, who lack the patience to complete the tests, and sometimes do not even understand the directions, are eliminated, there is found to be a correlation of only about .15 between these capacties and general intelligence. The highest correlation, .20, is with the discrimination of color, which is really a physiological capacity that one might not expect to be correlated with intellect at all.[6] Similarly art appreciation, although depending largely on education, or rather on the opportunity to acquire good taste, is correlated to the extent of only about .25 with general intelligence, among college students.[5] And the tests of originality and imagination now in use, though by no means perfect, show little or no correlation with the abstract intellectual capacities.

Art Runs In Families

In short, the talents which make a visual artist are innate and, above a minimum level, not much related to the talents which make a child the pride of his pedagogues. The extent to which they are inherited as well as inborn remains to be determined. The fact that artistry runs in families is susceptible of several interpretations. But as not only ordinary vision but color vision is definitely governed by

inheritance, it is probable that many other capacities requisite in an artist are likewise determined by his genes; and on the other hand that some of them, as in the case of the musician, are by-products of the fine adjustments of growth, hence not inheritable.

Recently developed tests make it possible to predict with a good deal of confidence whether a child has any talent for drawing. Evidently, most of this talent has been going to waste in the past, while thousands of children with no real capacity were dragged through art lessons, just as through music lessons, because their parents had the necessary money and ambition. With more careful study of children, much real talent will be found in unexpected places. The encouragement of such talent will not necessarily produce a great artist, for, in addition to the fundamentals such an artist has other characteristics that are not common: he is marked by a high degree of esthetic feeling and a desire to excel; by originality, belief in his own powers, and a willingness to work persistently with a distant end in view.

Rhythmic Expression

The autobiography of Isadora Duncan is a valuable document for the study of emotional expression in childhood, and the combination of circumstances that made her a dancer stands out boldly: inherited sensitivity of the feelings, intelligence, and lack of inhibitions on the one hand; on the other hand an infancy passed in a world of music, and a strong drive for self-expression in the thing which she could do best, to compensate for the feeling that her home life was a failure.

Acting ability usually develops early (compare the infantile film stars); indeed, any normal child shows, at the age of two or three, dramatic tendencies that seem later to be repressed, and it is an easy assumption that histrionic superiority in later life is favored by the absence of those inhibitions to which the average child inevitably succumbs. Anyone who has seen a show put on by the inmates of an institution for mental defectives will recognize the facts. The desire of many intellectually subnormal children (and adults) to "get into the limelight" is almost diagnostic; and some members of the theatrical profession have been suspected of the same ambition.

While there have been actors of high intelligence, it is generally supposed that intellect is not only a superfluity, but may even be a handicap. A professional concert pianist became premier of Poland, but there is no record of a professional actor holding such a position. A few men who afterward became eminent have shown exceptional histrionic gifts in youth: Cardinal Mazarin was distinguished in this respect, and Alfred E. Smith is said to have owed some of his popularity as a young man to his talent in amateur theatricals. A few eminent men have even displayed the same ability in adult life, particularly men belonging to the more extraverted Latin peoples; most of those who come to mind were not great men, but merely brilliant scoundrels, like Napoleon Bonaparte. Among English statesmen who "acted" in their official capacities the Earl of Chatham is conspicuous. The most consummate actor who ever achieved prominence in American public life was doubtless Patrick Henry, but he confined his theatricals to speeches, where their effect was successful—never more so, according to contemporary accounts, than in the speech for which he is alone remembered by a large part of posterity, that ending "Give me liberty or give me death!" In public life off the rostrum he was a model of dignity and restraint.

Intelligence and the Stage

Psychoanalysts say that acting disintegrates the personality; but is it not often disintegrated at the start? For one reason or another, men of outstanding intellectual ability drop acting quickly, if they dabbled in it during youth. Ben Johnson pulled on his learned sock and stepped out of the profession as fast as he could, leaving

Will Shakespear to act in his plays; even Shakespear, after his youthful experience, contented himself with the rôle of the ghost in *Hamlet*, not aspiring to portray the introverted Dane himself. And while many people consider him a great dramatist, few lists would rank him among the great actors of the world; nor did he himself have any great respect for most of the members of his profession, he would as lief the town crier spoke his lines. On the other hand, Charles Dickens' insight made the poor, half-starved moron Smike, the protege of Nicholas Nickleby, at once recognized by a producer as a drawing card.

"'Why, as he is now,' said the manager, striking his knee emphatically; 'without a pad on his body, and hardly a touch of paint on his face, he'd make such an actor for the starved business as was never seen in this country. Only let him be tolerably well up in the Apothecary in *Romeo and Juliet*, with the slightest possible dab of red on the tip of his nose, and he'd be certain of three rounds the moment he put his head out of the practicable door in the front grooves O. P.'"

And sure enough, the experiment being made, "Smike was pronounced unanimously, alike by audience and actors, the very prince and prodigy of Apothecaries."

Currency has been given to the fact that some of the show girls of the New York Follies passed remarkably high intelligence tests, ranging up to 180 IQ: but not even the most optimistic press agent ever claimed that these pulchritudinous females are actresses. At a more prosaic level, the army's drag net caught all sorts of fish, averaging *C* in intelligence, but the vaudeville actors averaged only *C*—while the "artists" (sign-letterers) and "musicians" (band) averaged *C*+.

The ability to impersonate all sorts of characters is scarcely compatible with the permanent possession of any strong individual character, and is therefore probably not compatible with the possession of a strong and well-balanced intellect. The progress of amateur theatricals now so popular in the United States may throw more light on this point. At present histrionic ability is indicated as not much associated with general intelligence, but associated rather with personality traits and lack of inhibitions that are to a large extent inherited.

In any art the standards of taste are largely subjective, and tastes change; but a book or picture at least exists for the study of successive generations. The actor, on the other hand, is seen by only a few, and his later reputation depends on hearsay, much influenced by press-agentry. Hence it is all the more difficult to draw a sharp line between the sort of talent which history praises and the sort that contemporaries acknowledge by the contribution of adolescent eggs and senescent tomatoes.

Literary Abilities

So little can be said definitely about the inheritance of literary talent that I omit it here. The many examples of it running in families may prove much, but do not necessarily prove anything. Illustrations like Tom Chatterton are sufficient evidence that the capacity is to a large extent innate. The discovery that a poet is born, not made, was not original with Q. Horatius Flaccus. Lope de Vega dictated verses at the age of five, before he had learned to write, and his illegitimate son had gained some fame as a poet by the age of 14. Then there is the familiar gibe at the hymn-writer Isaac Watts, who, when a child, worried his mother so much with his incessant versifying that she spanked him to stop the habit: as he felt the impact of the maternal sole he sobbed out,

O mother, on me pity take,
And I will no more verses make!

Experiments made in a few modern schools, where children are taught to express themselves in verse, show that ability in this direction is a much more nearly universal possession of the human mind than is sometimes admitted,

and that if it is rare in later life it is largely because the educational system succeeds in killing it. The fact that poetry flourishes particularly during the "childhood of the race" may be interpreted in the same way. But the difficulty of separating inborn capacities from cultural acquirements is particularly great in the field of literature, and as yet no studies of inheritance have been made that can be considered critical.

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Contriving the Elephant and the Butterfly

Excerpts from a Biology Text of a Century Ago

THE elephant, as you saw, is a very tall animal, and his head is a good way from the ground; and yet his neck is very short, so that he cannot, without kneeling, or lying down, bring his mouth to the ground.

This short neck, so different from that of other animals, whose heads are far from the ground, has one great advantage. It makes it so much the easier for the elephant to support the weight of his very large head and heavy tusks.

But somehow or other, the difficulty of having so short a neck, especially in getting food and drink, was to be remedied. And the admirable trunk, which God designed, and made, on purpose for the elephant, removes entirely all this difficulty. Still more, it has many advantages, and very great ones too, over the long necks of

other animals. . . . Mr. Cuvier, a very learned man, in France, who knew a great deal, and who wrote several curious books, about the different kinds of animals, tells us, that he has found, *there are more than thirty thousand distinct mucles in the trunk of an elephant!*

To a great many insects, jaws would have been useless. All the food which they take, is liquid. Moths and butterflies are of this kind. They eat nothing but honey, which is often quite deep, at the bottom of flowers. They need some way, then, of being able to reach it; just as we need some way of getting water from the bottom of a well, before we can drink it.

God has furnished them with just what they need.

They have a slender tongue, hollow inside, like a tube, and sometimes three inches long, which, when they do not use it, they coil up in a small space, that it may not be in the way, or get injured.

When they use it, they unroll it instantly, and darting it into the bottom of a flower, draw up the sweet juice or honey, on which they feed.

This tongue is a hard kind of flesh, made up of a great many little rings, which lie one above the other, and are moved by an equal number of muscles.

Though it looks very simple, and as it were only one tube, it is, in fact, made up of three, smaller, distinct tubes; the two outside ones to draw in the air, and the middle one to suck up the honey. This middle tube is nearly square, and formed by the two outside ones coming close together, with a channel, or trough, cut in each.

These two outside tubes are held fast together by a great many little hooks on each, that hook into each other; somewhat as you can hook the fingers of one hand, on to the fingers of the other, and hold the hands very tight together.

The insect can unhook these outside tubes, or hook them together again, whenever it pleases.

When they are hooked together, *the inside tube is air tight;* that is, no air can possibly pass through its sides. When the insect puts this tube down into the honey, and sucks up the air that is inside of the tube, the air at the bottom of the flower presses the honey up into the tube, and up into the mouth of the insect.—*The Class Book of Natural Theology for Common Schools and Academies.* By Rev. T. H. Gallaudet, 1837, Second Edition, Pages 111-112, 144-145—A work that should not be overlooked in tracing the history of biological instruction in secondary schools. The preface concludes with the following interesting observation:

> The author will only add, that having intended what he has written for young persons, he has gone into a minuteness of analysis, and a specification of details, which, his own experience has fully convinced him, is the only sure mode of conveying distinct ideas to those, whose powers of generalizing are but, as yet, imperfectly cultivated and developed.

FERTILITY OF COLLEGE GRADUATES

I. A Comparison of the Average Size of Family of Married Graduates with That of Married Women of Colonial Stock

WELD A. ROLLINS
Boston, Mass.

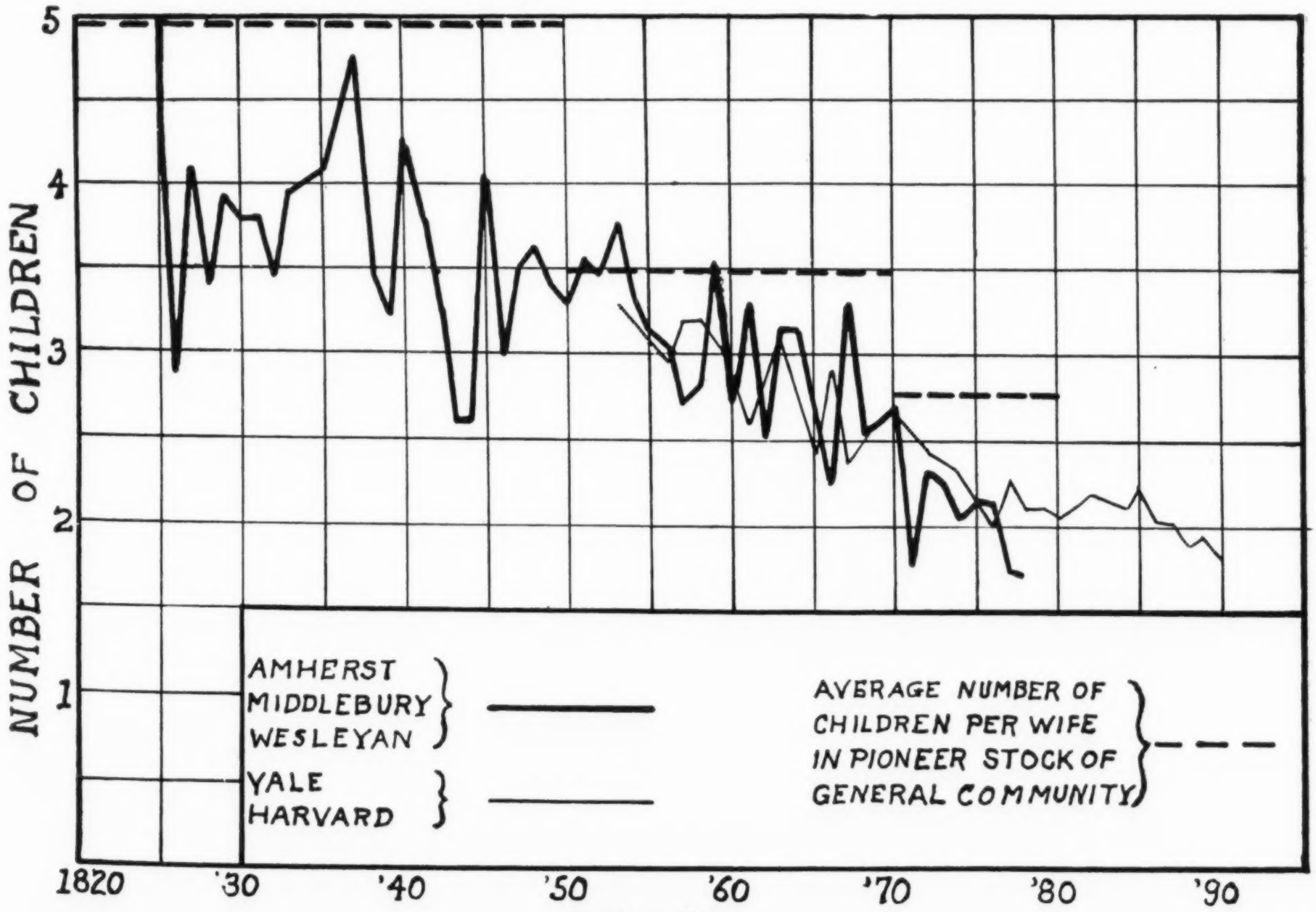
BY STUDYING genealogies of twenty-two American pioneer families which originally settled in New England and the Middle Atlantic States, Crum ascertained the fertility of wives of Colonial stock averaged for the most part in fifty-year periods.*

One of Crum's observations as to the facts brought to light by his investigation is:

> If the genealogical records teach anything, it is this, that unless a radical change is effected very soon, the stock which founded this nation and which nurtured it through the grave perils and trials of the formative period, will soon have vanished from the face of the earth.

Thanks to the researches of G. Stanley Hall† and Doctor John C. Phillips‡, it is possible to state the average number of children born to the graduates of certain colleges over periods tolerably comparable with Crum's figures above mentioned. See Table I.

It will be seen that the college graduates constantly averaged substan-



COLLEGE AND PIONEER BIRTHRATES

Figure 11

Average number of children born per married graduate of colleges compared with average number of children born per colonial wife.

Jour American Statistical Association, 14: 215. 1914.
†*Pedagogical Seminary*, 10:275. 1903.
‡*Harvard Graduates Magazine*, 25:25. 1916.

tially less children than the wives of colonial stock—about one-fifth less.

Continuing a little further with the comparison between the average number of children of married college graduates and those of wives of colonial stock as reported by Crum, the period between 1825 and 1890 is also covered in a slightly different way by the graph. entitled Figure 11.

The various sources of information above referred to, and a study by Banker as to the graduates of Syracuse University, make it possible to compare also the number of childless marriages of college graduates and those of the wives of colonial stock. The comparison is presented in Table II.

It will be seen that with the exception of Amherst between 1872 and 1878, where for various reasons I believe the figures to be incomplete, the graduates have had ever so many more childless marriages than the colonial

Table I. Family size of college graduates and of colonial stock 1658-1878.

Graduation Periods.	1. No. of married graduates	2. No. of children born	3. Average no. of children born per married graduate	4. Average number of children born per wife of Colonial stock as found by Crum	5. Ratio of average number of children per graduate to average number of children per wife of Colonial stock
Harvard 1658-1685 inclusive	88	460	5.23	Prior to 1700) 7.37	71%
Yale 1702-1751 inclusive	470	2611	5.55	1700-1749) 6.83	81%
Yale 1753-1762 inclusive	277	1368	4.94	1750-1799) 6.43	77%
Amherst 1825-1851 inclusive	791	2981	3.77	1800-)	76%
Various colleges 1812-1851 inclusive	45	160	3.81	) 4.94 1849)	77%
Yale 1850-1859 average of nine years	750 (about)	2471 (about)	3.32	1850)	
Yale 1861-1870	864 (about)	2336 (about)	2.69	) 3.47 1869)	86% (about)
Yale 1871-1880	945 (about)	2119 (about)	2.23	1870)	81%
Harvard 1870-1878 inclusive	979	2112	2.16*	) 2.77 1879)	78%

*Phillips makes this, for the period 1871 to 1880, 2.23, which I suppose is more nearly correct.

wives. Does this imply lack of fecundity on the part of the graduates, or is it because of later marriages, or economic and social considerations?

The steady, uninterrupted two hundred year decline in the birth rate of the colonial wives and of the college graduates has had for its predominant cause, it seems to me, the increasing difficulty of making for one's self and a wife and children a living substantially as good as others of the same social class. If it be assumed that this analysis is substantially correct, what is the cause of the consistently inferior fertility of the college graduates? May it not perhaps be the same thing? In other words, may it not be that, among other causes, the college graduates have, during the age at which children are born, found it harder to attain the standard of living of their social class than other people of like age have found it to attain the standard of living of their social class?

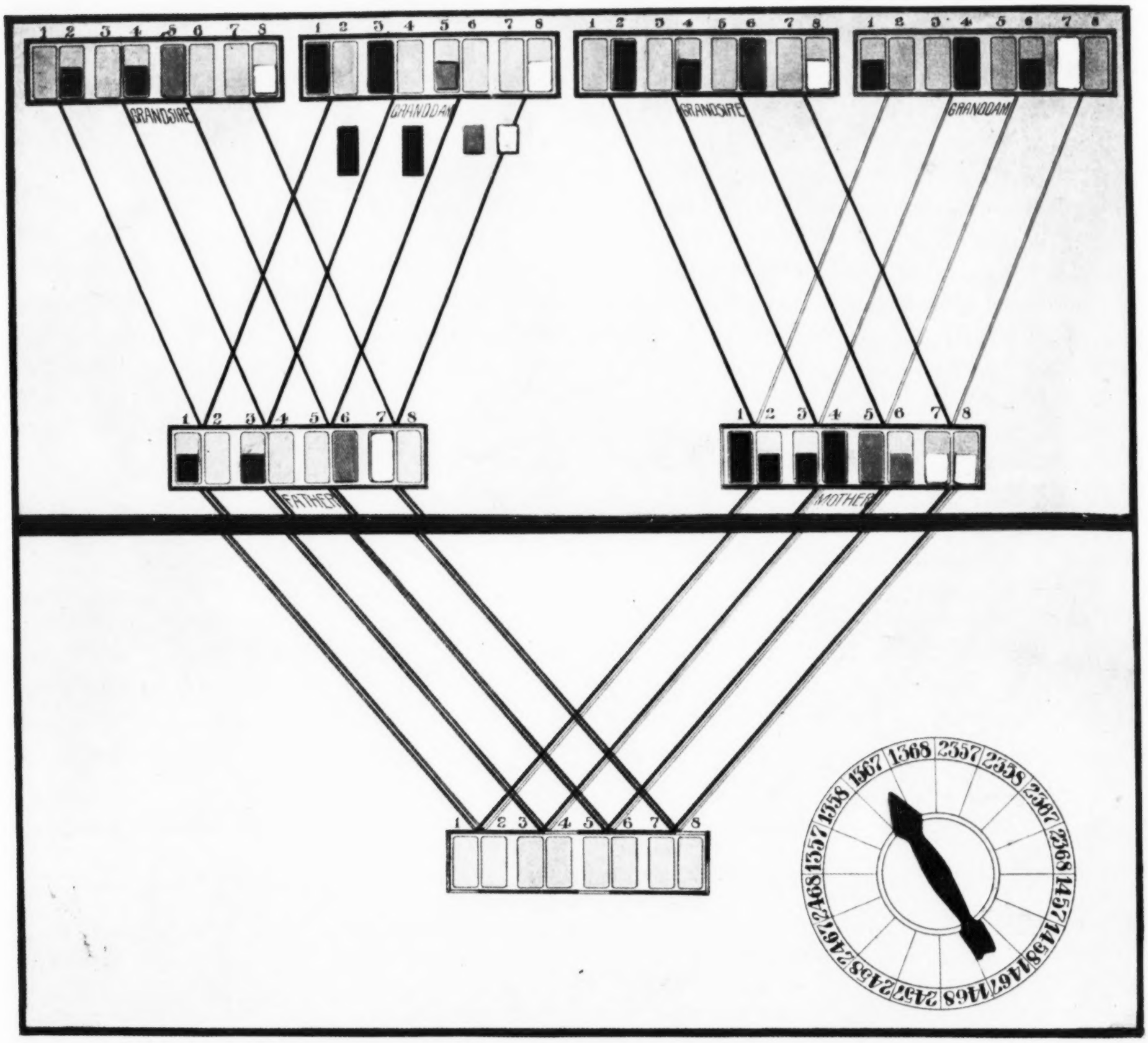
Whatever the true explanation may be, there seem to have been at work forces common both to the colonial wives and the college graduates and tending towards the gradual extinction of the stock of each. In addition, either these forces have operated more powerfully on the college graduates than on the colonial wives, or there have been additional forces operating on the college graduates.

Moreover, there is not much in the figures to suggest that the differential between the two groups is likely to correct itself. If this is a legitimate inference, nad if conditions are not changed, it would seem to follow that, inasmuch as we are approaching nearer and nearer to a stationary population, the graduates of Liberal Arts Colleges will, in the future, as at all times since 1860 or 1870, find themselves unable on the average to perpetuate themselves. This means that selected strains will continue to die out, and, immigrants coming in and having children, the type of the population, and its family and group tradition, will continue to change. Whether the phenomena that we are witnessing are, or may be, such as cause or are associated with national decadence seems to me to be a subject worthy of careful study.

Table II—Percentage of childless marriages of college graduates compared with the percentage of childless colonial wives as reported by Crum

Graduation periods of graduates	% of childless marriages of graduates	% of childless colonial wives	Marriage periods of colonial wives
		1.81	Before 1700
		1.74	1700 - 1749
		1.88	1750 - 1799
Amherst 1826-1849	11.	4.07	1800 - 1849
Yale 1850-1859 Yale 1861-1870	14.3) 19.1)	5.91	1850 - 1869
Amherst 1872-1878 Syracuse 1872-1881 Yale 1871-1880	7.) 14.) 20.3)	8.10	1870 - 1879
Yale 1881-1890	21.		
Harvard 1891-1900	26.1		

A DEMONSTRATION OF THE HEREDISCOPE

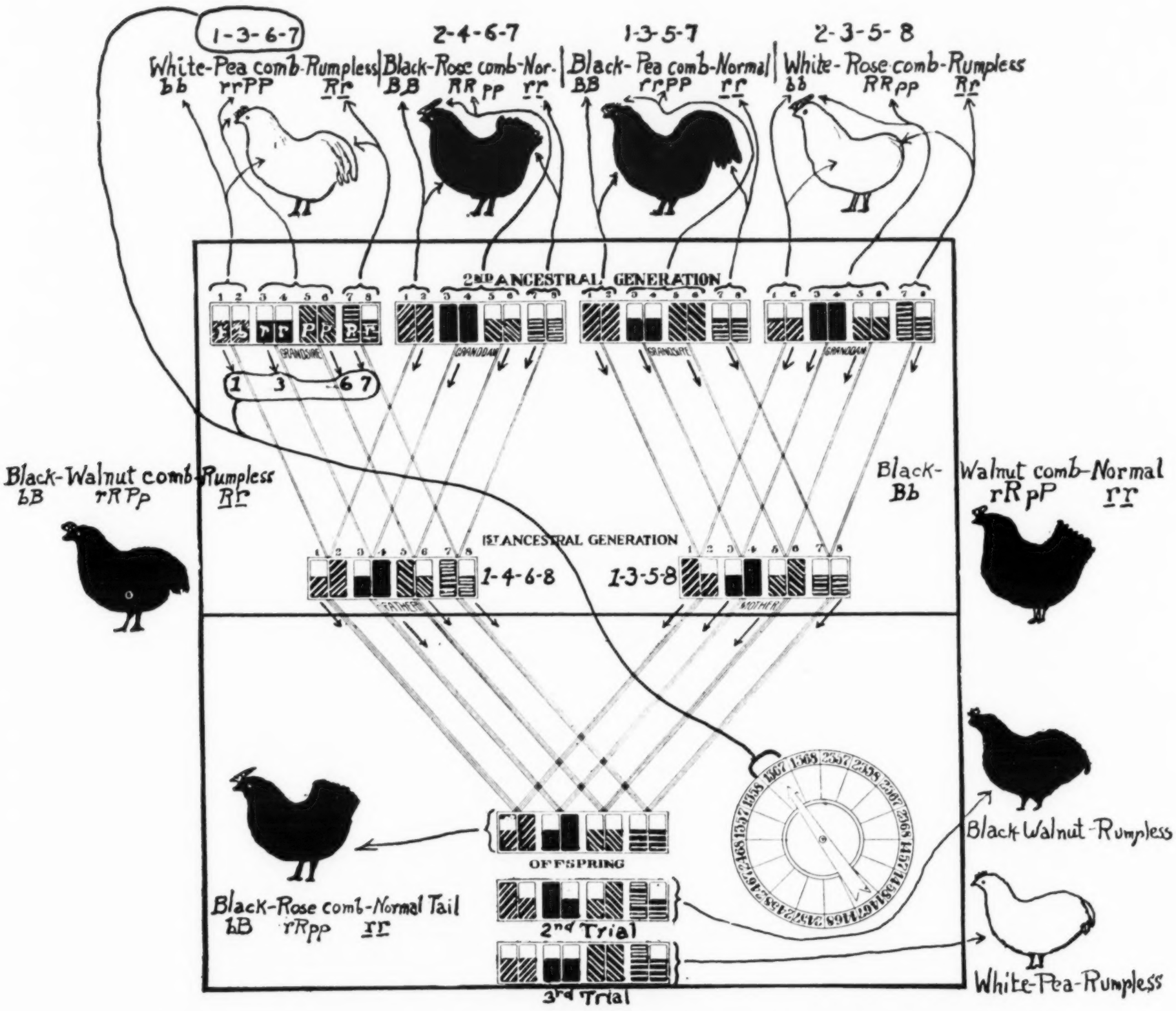


THE HEREDISCOPE

Figure 12

This shows the herediscope arranged for demonstrating the inheritance of the four pairs of characters shown in Figure 13. The colored character-blocks are represented by four different shades. The element of chance that determines which of each pair of allelomorphs actually is selected in any given mating is furnished by the revolving pointer at the right. It indicates that blocks on "chromosomes" 1-3-6-7 are transmitted, and these are shown moved down to form half the genotype of the "father." Blocks on 2-4-6-7 (the next "throw") are shown moved part way down. These will complete the genotype of the "father." In the "mother" the blocks are all in place, one from each pair in each of her "parents."

THE simplified herediscope announced in the March JOURNAL has been perfected and is ready for distribution. The accompanying illustration (Figure 12) shows how the device looks and the drawing (Figure 13) shows its method of operation. The device is based on the principle that the choice of one of a pair of allelomorphs actually transmitted in a given mating is determined by chance. The paired chromosomes are represented by paired rectangles on the herediscope chart—an "individual" being represent-



A HEREDISCOPE DEMONSTRATION OF POULTRY HEREDITY

Figure 13

This shows the inheritance of four pairs of alternative characters (allelomorphs) in poultry: plumage color (black-white); type of comb (rose or pea—two independent characters. The combination of these produces walnut combs; the double recessive produces single combs); and type of tail (normal tail *vs.* rumpless). Long blocks represent dominant characters; short blocks, the recessives. Thus the "paternal grandsire" is a white, pea combed, rumpless individual of the genetic constitution *bbrrPP***Rr**.

ed by a group of four pairs of chromosomes. The genes or actual characters are represented by colored counters of two lengths, long representing dominants and short representing recessives. The element of chance is furnished by a revolving pointer which is spun to indicate which of each pair of alternative characters is chosen in any given mating.

The explanatory chart (Figure 13) illustrates a cross between fowls differing in four pairs of allelomorphs (alternative characters): Color (Black-white); two-comb characters (Rose-single; Pea-single), and normal tail versus rumplessness. On the herediscope each pair of characters is assigned a "color-equivalent" (the colors are indicated by shading on the chart) and the characters are represented by oblong colored "counters" or 'character blocks". Thus if black is assigned to the black-white character pair, with black dominant as in rose-comb bantams, the long black blocks represent black and the short black blocks represent the recessive alleomorph, white.

Thus a black individual may be represented either by two long black blocks or by a long and a short one. A white individual is always represented by two short blocks.* The Black-white character pair is assigned to one of the character-pairs of the Herediscope (1-2 in the chart), and the others are assigned to the remaining pairs: the two comb-character pairs to the second and third pairs (3-4 and 5-6), and the rumpless-normal tail pair to the fourth (7-8).

In ordinary mendelian inheritance one of each pair of allelomorphs can take part in a given mating, chance determining which is actually transmitted. The rotating pointer on the herediscope furnishes this element of chance. Around it are arranged the sixteen possible combinations of one element from each of the four pairs. Spinning the pointer indicates which one of each allelomorphic pair actually participates in a given mating. In the example the first spin of the pointer gave the numbers 1-3-6-7, so that in this mating the blocks on "chromosomes" 1, 3, 6, and 7, are moved down to the next generation. The next spin gave the combination 2-4-6-7, and in this mating these blocks complete the genetic constitution of the "father" in the first ancestral generation. This individual is black, walnut combed† and rumpless, being heterozygous for all four pairs of characters. The next two spins of the pointer gave 1-3-5-7 and 2-3-5-8, which results in a black, walnut-combed, normal-tailed individual, the recessive allelomorph of rumplessness having been chosen in the case of the white rumpless granddam.

In the next (offspring) generation, the results are shown of three matings of the same parents in the first ancestral generation. The first "mating" produced a black, rose-combed individual with normal tail. The second produced a black walnut-combed rumpless individual, and the third a white, pea-combed rumpless. Additional trials would show the remaining possible combinations. As the number of trials is increased the proportions obtained would approach more and more closely to those expected by theory.

There are so many possible combinations in a cross involving four pairs of characters (theoretically 81 genetically different combinations and 256 possible combinations of gametes‡ that working out the proportions of each combination would pe a rather extensive problem. Taking two or three pairs and leaving the other spaces blank reduces the complexity and the labor in demonstrating the proportions. The construction of a "checkerboard" of possible genetic combinations is a process that sometimes appears to lack reality to the beginning student and to the searcher for information about heredity. By combining the checkerboard method with the herediscope we see how the combinations occur and thus add much to its effectiveness.

In most genetic experiments the two strains that are crossed differ only in one gene or character—at least that is the ideal situation for experimentation. To illustrate such crosses only one pair of spaces need be used, but it is probably more illuminating to fill the other spaces with like pairs of blocks—em-

*In the case of color-characters it may be advantageous to visualize the color by having the allelomorphs of different color, but in most instances this is likely to lead to confusion. In this instance a short white block could be used to represent recessive white.

†Walnut combs are produced by the interaction of the factors producing pea and rose combs. Thus individuals of the genetic constitution *RRPP*, *RrPp*, *RRPp*, *RrPP*, have walnut combs. Those of the constitution *rrpp* have single combs.

‡This would be complicated in the case of rumplessness by the fact that rumplessness in the homozygous condition is believed to be lethal. For this reason rumpless birds are shown as heterozygous in the 2nd Ancestral Generation, when to make this a perfect example of a cross involving four character pairs they should be homozygous. The peculiar relations of Rose and Pea comb also alter the number of classes.

phasizing that the rest of the heredity is there, but being alike it is constant for purposes of the experiment For visualizing the process of Mendelian heredity it is desirable to use all four pairs, thus showing the wide range of variation that is produced by random combination of a small number of characters.

In the following article Mr. Graves explains the use of the Herediscope in multiple-factor inheritance. The ways in which it can be used to demonstrate such important cases of Mendelism is one of its most promising applications. A chart illustrating the inheritance of stature in man along the same lines is in preparation. This can be extended in a similar manner to egg-laying in poultry, stature in man, shape in squash, and many other examples.

A HEREDISCOPE DEMONSTRATION OF DAIRY CATTLE IMPROVEMENT

Illustrating Hereditary Transmission of Milk and Per Cent Butter Fat with the Herediscope

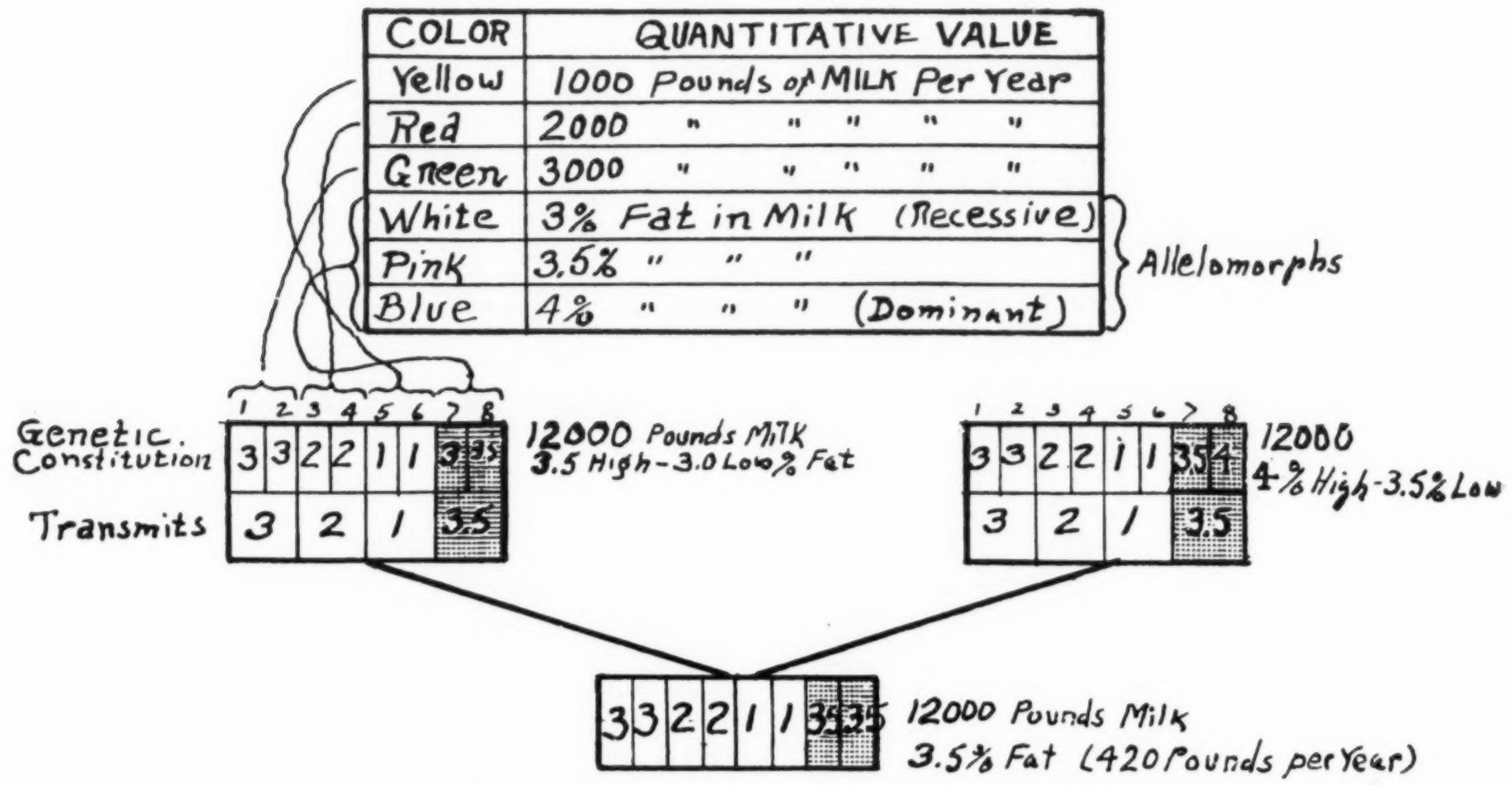
R. R. GRAVES
Bureau of Dairy Industry

IT is questionable if the number of factors that enter into the determination of the yearly production of milk and butterfat will ever be definitely known. Nor will the definite values of the various factors be known. The size of the Herediscope limits us to the use of four pairs of multiple factors. The use of four pairs of factors illustrates the mechanism of the inheritance of milk producing capacity as well perhaps as would eighteen pairs. By assigning arbitrary values to the factors the results show a distribution of records quite closely approaching that of the daughters of sires in our own herds.

A difference in the values assigned to the factors will have to be made according to whether the non-dominant cumulative hypothesis is followed, or whether the higher-valued allelomorphic factor is considered dominant over the lower. Our experience in securing high producing daughters, when mating sires that are proved to have an inheritance for a high level of production, to dams of medium or low producing capacity, leads us to believe in the dominance of the higher valued allelomorph over that of the lower. In the illustrations that follow, the first three pairs of allelomorphic chromosomes have been assumed to be those carrying the factors determining milk yield, and the fourth pair to carry the factors determining per cent of butter fat. For the per cent butter fat, due to restriction to one pair of factors, only three values have been used, namely 3, 3.5 and 4 per cent, covering the average range of per cent fat in milk from Holstein-Friesian cattle. For the same reason the higher valued allelomorph has been assumed to be dominant over the lower. For the milk yields arbitrary values have been given to factor determiners as follows: 1,000, 2,000 and 3,000 pounds; in the illustrations where dominance was assumed these values were doubled, that is: 2000, 4000 and 6000 pounds. On the charts the figures indicating milk yield represent thousands of pounds.

Cumulative Inheritance

To determine inheritance for milk yield, in the charts where the cumulative, non-dominant theory was used, all the allelomorphic or duplicate fac-



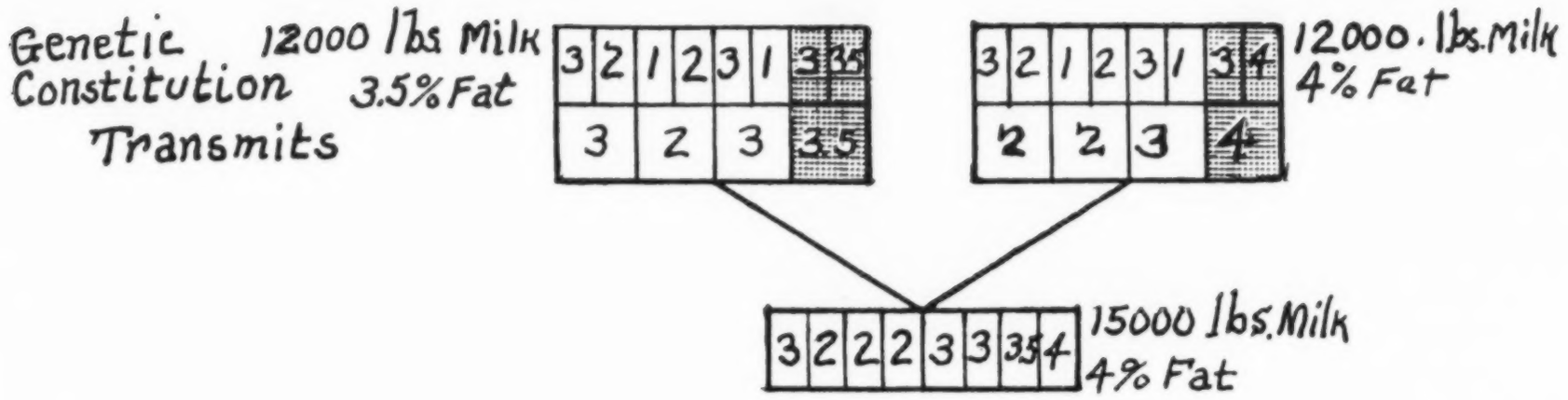
AN EXAMPLE OF MULTIPLE FACTOR INHERITANCE

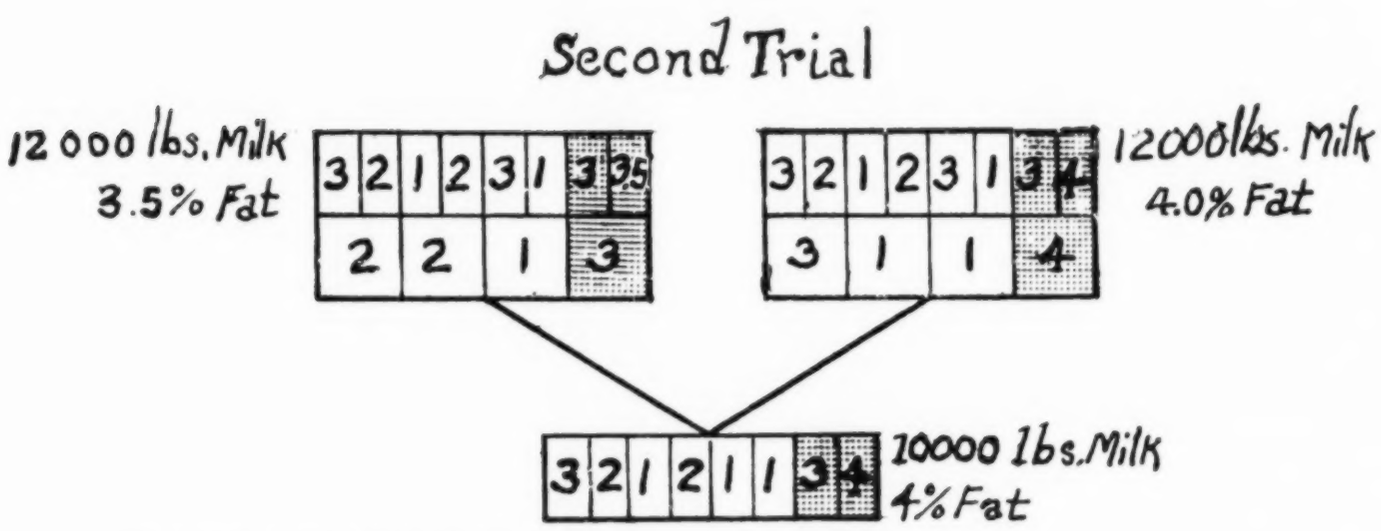
Figure 14

Under the same conditions closely related animals will vary tremendously in the amount and quality of the milk they produce. This difference in producing capacity is due to an unknown number of genetic factors each of which has an effect on the total yield. In this example three factors are considered to control rate of milk production, and one pair (stippled) the per cent of butterfat in the milk. The milk-rate factors are considered to be non-dominant and cumulative; the higher percentage of butterfat is considered to be dominant over the lower. The parents are both homozygous (pure) for the factors controlling rate of milk production but vary in the butterfat factor. The offspring will all be 12,000 pound producers, but some of them will produce milk containing 3.5 per cent fat, and the others will produce milk having 4 per cent fat.

tors were added. In the charts illustrating transmission of milk yield, where dominance is assumed, the factor determiner for the higher yield, of each of the three factor pairs is added. This result gives the maximum capacity of the animal for milk yield. The factor determiner for lower yield, of each of the three factor pairs, is also added. This result we assume indicates the minimum transmitting ability for milk yield of the animal. If the sum of the addition of the three factor determiners for the higher yield, out of each of the three factor pairs, is 16000, and the sum of the three factor determiners for the lower yield, of each of the three factor pairs, is 8000, this would indicate that the animal might be a 16000 pound producer, under the right environmental conditions, and that she might transmit as high as 16000, as low as 8000, or various amounts between these two extremes. This method shows some interesting recombination values. One parent may transmit 12000 and the other 8000 pounds of milk, at a given mating, and the offspring may have a genetic constitution showing a maximum transmitting ability of 14000 and a minimum transmitting ability of 6000 pounds milk.

The first chart, Figure 14, shows two animals that are homozygous, or pure, for 12000 pounds of milk using the cumulative, nondominant method; and heterozygous, or mixed, for per cent fat. The factor determiners in each allelomorphic pair are the same in each individual and are the same in the corresponding pairs in both animals. Both of these two animals can therefore transmit only 12000 pounds milk at any mating. Consequently all the offspring of these two animals will


Genetic Constitution
12000 lbs Milk 3.5% Fat
Transmits
3 2 1 2 3 1 3 3.5
3 2 3 3.5
3 2 1 2 3 1 3 4
12000. lbs. Milk 4% Fat
2 2 3 4
3 2 2 2 3 3 3.5 4
15000 lbs. Milk 4% Fat



HETEROZYGOSITY CAUSES VARIATION

Figure 15

The butterfat factors carried by the "parents" in this mating produce the same quantity of milk as those in the previous example. They are arranged differently however, with the result that offspring vary greatly in rate of milk production.

THE RESULT OF 60 TRIALS

Table I. The result of sixty herediscope trials of the "individuals" shown in Figure 15, showing milk per year, per cent fat and total fat per year. Below the detailed table is a summary showing that of the sixty "individuals," two produced as low as 9,000 pounds of milk, and two as much as 16,000 pounds.

Trial	Milk X1000 lbs	Fat %	Fat lbs-Year	Trial	Milk x1000	Fat %	Fat lbs-Year	Trial	Milk X1000	Fat %	Fat lbs.-Yr.
1	15	4.0	600	21	13	4.0	520	41	11	3.5	385
2	10	4.0	400	22	13	3.0	390	42	11	4.0	440
3	13	4.0	520	23	14	3.5	490	43	12	3.5	420
4	12	3.5	420	24	10	3.5	350	44	10	4.0	400
5	13	4.0	520	25	14	3.0	420	45	11	3.0	330
6	12	3.5	420	26	13	3.0	390	46	14	3.5	490
7	16	4.0	640	27	11	4.0	440	47	12	3.5	420
8	13	4.0	520	28	12	4.0	440	48	10	4.0	400
9	12	4.0	480	29	13	4.0	520	49	15	3.0	450
10	13	3.5	455	30	10	3.5	350	50	13	3.0	390
11	11	4.0	440	31	14	3.5	590	51	9	4.0	360
12	11	4.0	440	32	11	3.5	385	52	13	4.0	520
13	10	3.0	300	33	11	3.0	330	53	11	3.5	385
14	13	4.0	520	34	13	3.5	455	54	14	4.0	560
15	12	4.0	480	35	10	4.0	400	55	12	4.0	480
16	11	4.0	440	36	10	3.0	300	56	12	4.0	480
17	10	3.5	350	37	16	4.0	640	57	12	3.5	420
18	15	4.0	600	38	9	3.5	315	58	13	3.0	390
19	13	4.0	520	39	15	4.0	600	59	13	4.0	520
20	14	3.0	420	40	13	3.5	455	60	14	3.0	420

Milk-X1000lbs.	9	10	11	12	13	14	15	16
1st 30 Trials	0	5	5	4	10	3	2	1
2nd 30 Trials	2	3	6	5	6	4	2	1
TOTALS	2	8	11	9	16	7	4	2

be homozygous, or pure, for 12000 pounds of milk but will vary in the per cent fat, from 3 to 4 per cent.

The next chart, Figure 15, shows two matings of animals, all of which are heterozygous for 12000 pounds of milk. While the genetic constitution of each animal is the same, the factors in each allelomorphic pair are different. This causes the two animals to transmit different values at the same mating and varying amounts at different matings. The amount transmitted will be seen in the chart opposite the word "transmits." The illustration shows one offspring receiving an inheritance for 15000 pounds of milk from its parents while the other receives from parents of the same genetic constitution an inheritance for 10000 pounds.

FOUR GENERATIONS OF PROVED SIRES
HUNTLEY, MONTANA
1919-1929
Varsity Derby Allen 256012
Pride of the Bess Burkes 294574
Daughters of Pride of the Bess Burkes
Friend Ona Hartog Korndyke 277648
Daughters of Friend Ona Hartog Korndyke
Mapleside King Paul 181023
Daughters of Mapleside King Paul
Foundation Cows

	Varsity Derby Allen 256012				Pride of the Bess Burkes 294574				Friend Ona Hartog Korndyke 277648				Mapleside King Paul 181023			
	No.	Milk	Butterfat P.Ct.	Butterfat Lbs.	No.	Milk	Butterfat P.Ct.	Butterfat Lbs.	No.	Milk	Butterfat P.Ct.	Butterfat Lbs.	No.	Milk	Butterfat P.Ct.	Butterfat Lbs.
Daughters	*15	13185	3.81	503.0	17	19669	3.51	689.2	5	17711	3.58	634.5	16	17888	3.57	639.5
Dams	15	9686	3.58	347.1	17	18321	3.25	592.3	5	16983	3.42	581.4	16	17129	3.43	587.5
Increase		3499	.23	155.9		1348	.26	96.9		728	.16	53.1		759	.14	52.0
Daughters which excel dams		14	13	14		10	14	14		3	3	4		11	10	13

*Daughters and dams Varsity Derby Allen were milked twice daily; others were milked three times.

A PROVED SIRE EXPERIMENT

Figure 16

Photo-chart showing the four sires used at the Huntley Station of the Bureau Dairy Industry. Mapleside King Paul was the first, and each of the succeeding sires has been mated to the daughters of his predecessor. Each has been chosen for his ability to produce a large proportion of daughters exceeding their dams in milk production and per cent of butterfat. It is hoped thus to produce in a few more generations a strain of dairy cattle pure for a fairly high level of milk production. The figures given below the illustration show the record of the daughters compared with their dams, the records of the daughters being calculated to maturity. The choice of sires on the basis of their daughters' performance is a new technique in cattle breeding, which eliminates many of the risks involved in selecting sires on the basis of the performance of their ancestry.

The variable constitutions that is possible to receive from heterozygous parents of the same hereditary make-up, is so interesting that we have run 60 trials—this would represent 60 offspring from parents of the same genetic constitution for 12,000 pounds of milk, with a per cent fat range of 3, 3.5 and 4. The results of these 60 trials are shown in Table I. The first column gives the result of each trial-mating—in thousands of milk, and of per cent fat—using the higher determiner in the alleomorphic pair, and

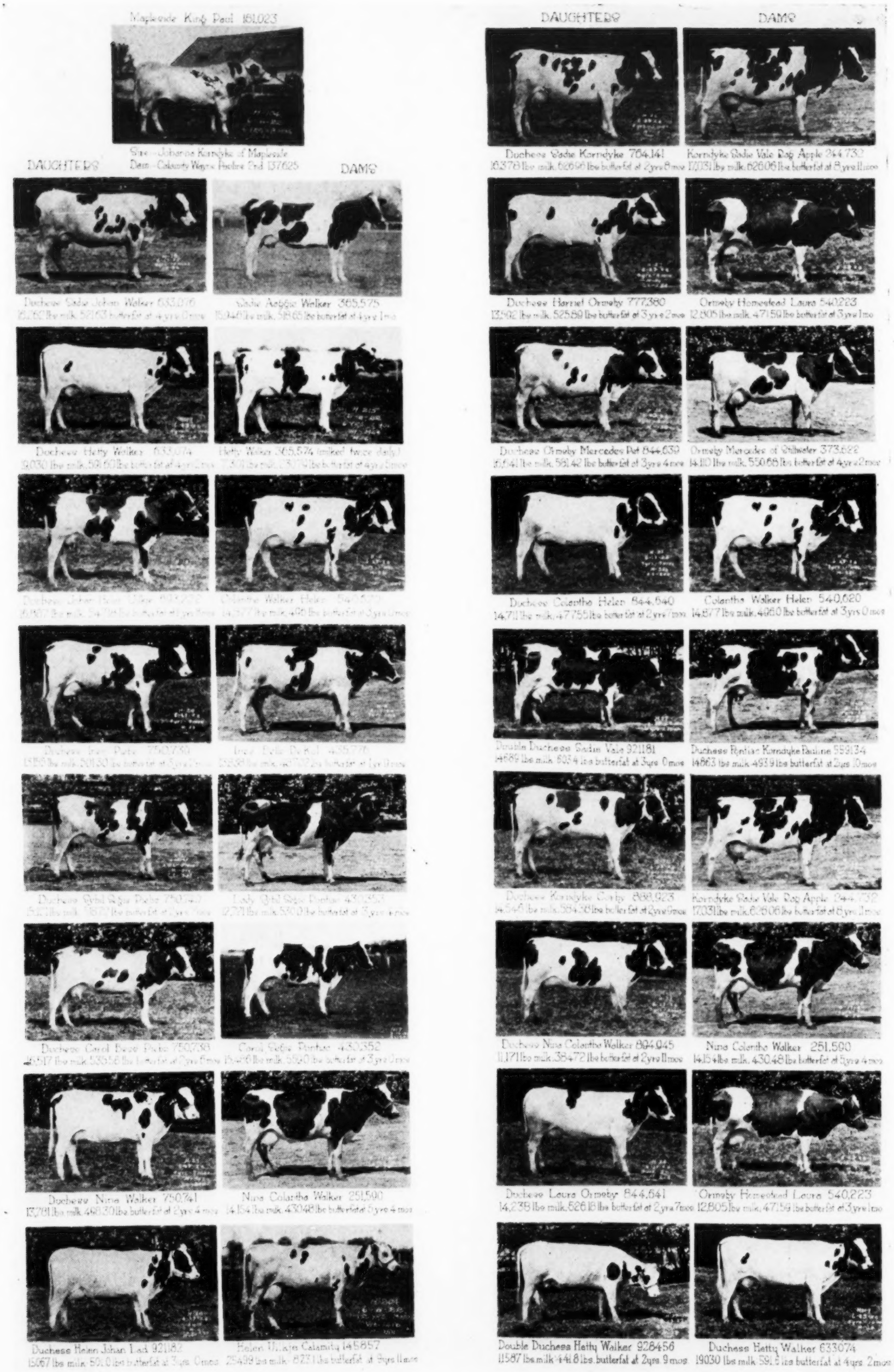
the third column gives the calculated product of these two figures in pounds of butter fat. The range of milk yield of these 60 sisters, if we may imagine the result of each trial to be the production record of a daughter of this sire and dam with the same genetic constitution for 12,000 pounds milk, is 9,000 to 16,000 pounds, and the range in pounds of butter fat was 300 to 640. The distribution of milk yields and per cent fat is shown in the table. To the dairy cattle breeder who has experienced discouraging "throwbacks" from high-producing ancestors, it will be illuminating to see how such ranges of milk yield and botter fat could be obtained from the mating of two animals of the same heterozygous genetic constitution for 12,000 pounds of milk.

In 1918 the writer inaugurated breeding experiments at the Field Stations of the then Dairy Division of the United States Bureau of Animal Industry, having for their object the building of herds that would be homozygous or pure in their inheritance for a high level of milk and butter fat production. The theory was advanced (1) that this might be accomplished by the continued use, for generation after generation, of sires that had proved through the production of their daughters, that they have an inheritance that will enable them to transmit high producing ability to all their offspring. (2) That sires whose daughters are uniformly high producers and of greater producing capacity than their dams, are homozygous for the hereditary factors that determine high producing capacity, and that if such sires were used for five or six generations a herd would be obtained which would be pure in its inheritance for this character. After this time, as long as sires "proved" for a high level of production, are used, every son and every daughter could be depended upon to

TABLE II—Production records of registered daughters and of dams of daughters of Mapleside King Paul 181023. From Technical Bulletin 116, U. S. Department of Agriculture. 1929

No.	Daughters						Dams					
	Age		Milk	Butterfat			Age		Milk	Butterfat		
	Years	Months		Per cent	Actual	Calculated to maturity	Years	Months		Per cent	Actual	Calculated to maturity
			Pounds		*Pounds*	*Pounds*			*Pounds*		*Pounds*	*Pounds*
1	4	0	16,262	3.21	521.6	573.3	4	1	15,946	3.25	518.6	570.0
2	4	2	19,030	3.11	591.6	650.2	4	5	7,301	3.16	230.8	253.6
3	2	8	16,887	3.24	547.2	684.0	6	11	18,146	3.29	596.8	596.8
4	3	2	13,155	3.81	501.3	589.5	1	9	13,838	3.52	487.0	695.5
5	2	7	15,121	3.43	518.7	648.4	3	4	12,721	4.17	530.0	623.3
6	2	6	16,517	3.24	535.5	669.5	3	0	15,486	3.61	559.0	657.4
7	2	4	13,781	3.62	498.3	664.2	5	4	14,154	3.04	430.5	443.8
8	2	8	16,378	3.83	626.9	783.7	8	11	17,031	3.68	626.0	626.0
9	3	2	13,592	3.87	525.9	618.4	3	1	12,805	3.68	471.6	554.6
10	3	4	16,641	3.49	581.4	683.7	4	2	14,110	3.90	550.6	605.2
11	2	7	14,712	3.25	477.5	596.9	6	11	18,146	3.29	596.8	596.8
12	2	9	14,546	4.02	584.4	730.5	8	11	17,031	3.68	626.0	626.0
13	2	11	11,171	3.44	384.7	480.9	5	4	14,154	3.04	430.4	443.8
14	2	7	14,238	3.69	526.2	657.7	3	1	12,805	3.68	471.6	554.6
15	3	0	14,689	4.11	603.4	709.6	2	10	14,863	3.45	493.9	617.4
16	3	0	15,067	3.33	501.0	589.2	9	11	25,499	3.23	823.1	823.1
17	2	9	11,587	3.81	441.8	552.3	4	2	19,030	3.11	591.6	650.2
Average [1]						640.1						584.6
Increase of daughters over dams						55.5						
Per cent increase						9.5						

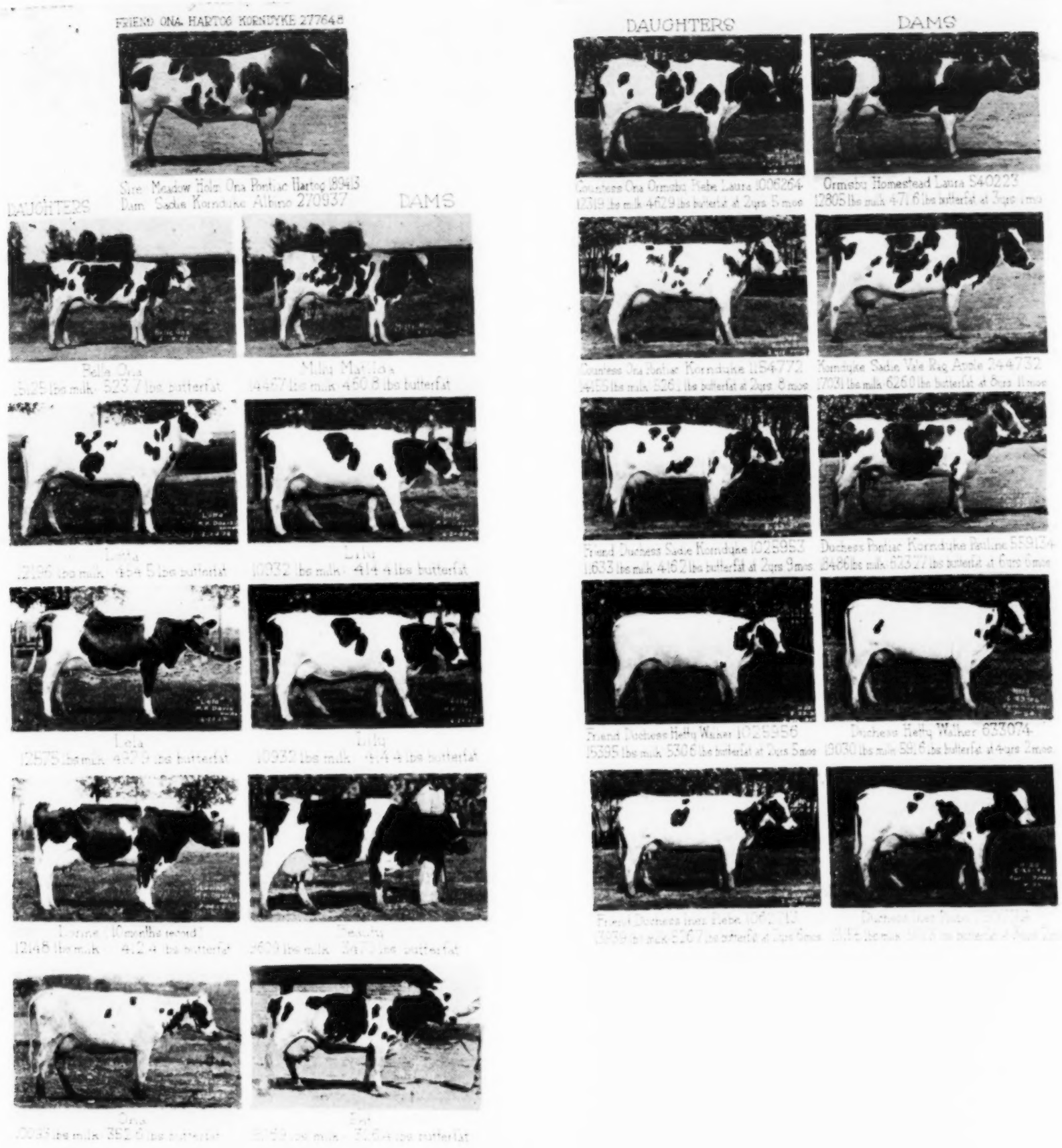
[1] 13 daughters exceeded dams in quantity of butterfat calculated to maturity, and 1 produced practically the same.


Mapleside King Paul 161,023
Sire—Johanna Korndyke of Mapleside
Dam—Calamity Wayne Pontiac 2nd 137625
DAUGHTERS
DAMS
Duchess Sadie Johan Walker 633,076
Sadie Aaggie Walker 365,575
Duchess Hetty Walker 633,074
Hetty Walker 365,574 (milked twice daily)
Duchess Colantha Helen 844,640
Colantha Walker Helen 540,620
Duchess Pontiac Korndyke Pauline 899134
Double Duchess Satin Vale 921181
Duchess Korndyke Cindy 868,923
Korndyke Sadie Vale Rag Apple 244,732
Duchess Nina Colantha Walker 804,945
Nina Colantha Walker 251,590
Duchess Laura Ormsby 844,641
Ormsby Homestead Laura 540,223
Duchess Helen Johan Lad 921182
Helen Wilkes Calamity 145857
Double Duchess Hetty Walker 928456
Duchess Hetty Walker 633074

MAPLESIDE KING PAUL AND HIS DAUGHTERS

Figure 17

Photographic record of daughters and their dams of the first sire used at the Huntley Field Station. The daughters are on the left, and opposite each daughter is her dam. Mapleside King Paul also tends to transmit, in addition to a high level of production, his predominately white coat-pattern.



THE SECOND "PROVED SIRE" AND HIS DAUGHTERS

Figure 18

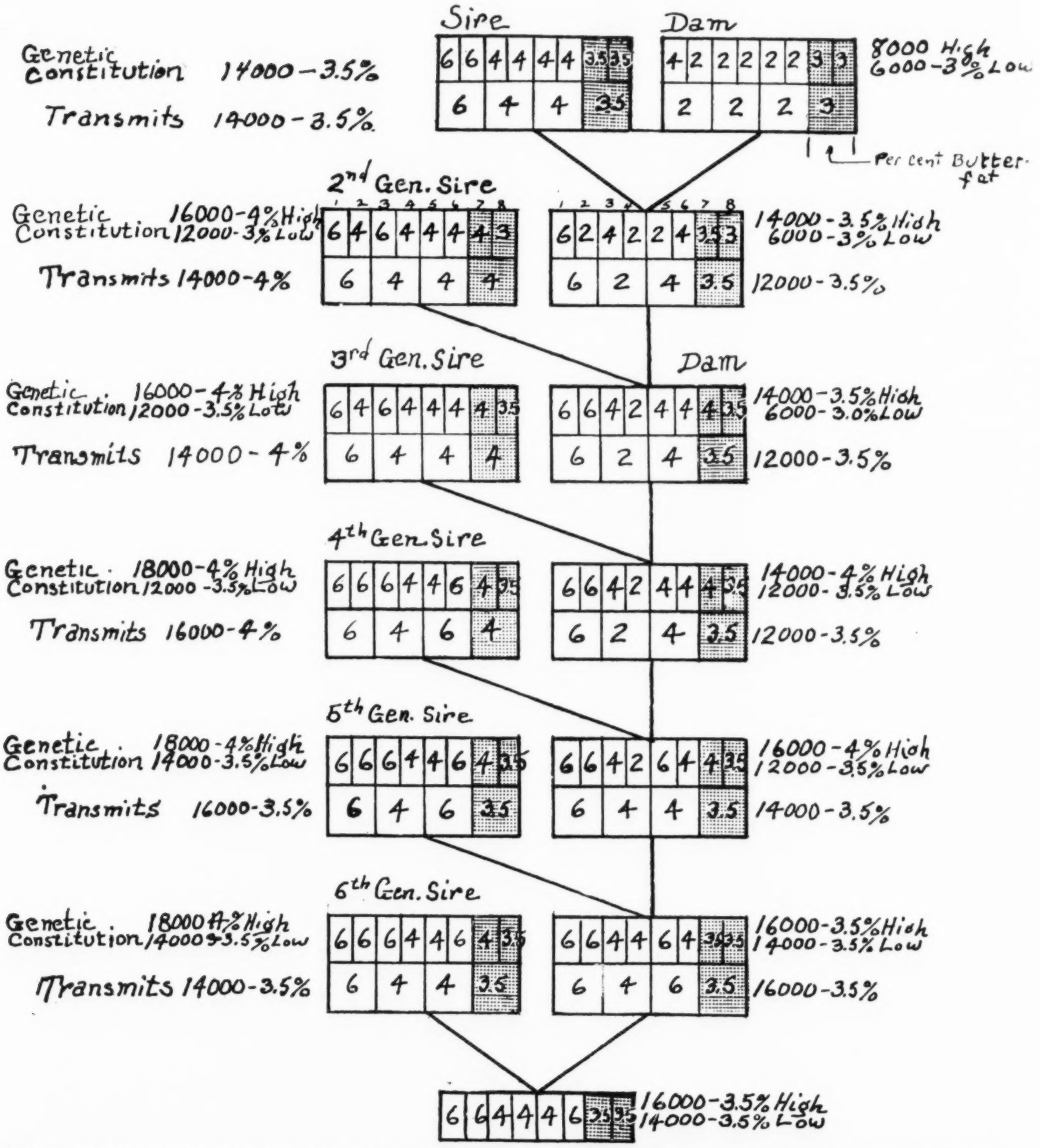
The daughters on the left are by Friend Ona Hartog Korndyke out of grade dams; those on the right have purebred dams. The proved sires are chosen on the basis of their daughters' performance. The Bureau of Dairy Industry is now making a photographic record of every cow used in its breeding experiments and is recording their development by photographs at frequent intervals.

transmit uniformly high production, and in addition, in the case of the females, to be high producers themselves. (3) The theory was also advanced that the record of a cow, did not necessarily indicate what she would transmit to her offspring at any given mating, that such a record might be an indication of only one part of her genetic constitution governing transmission of producing ability.

In a recently published bulletin,[4] a summary of the breeding work at the Huntley Field Station for the period of 1918-1927 is given.

A photographic chart is published herewith showing the daughters and their dams, of Mapleside King Paul, the first sire used at the Huntley Station. The following table shows the comparative records of the 17 daughters of this sire and their dams. These records are made without selection; that is, every daughter is tested regardless of her producing capacity,

COLOR	QUANTITATIVE VALUE
Yellow	2000 Pounds of Milk per Year
Red	4000 " " " " "
Green	6000 " " " " "
White	3.0% Fat in Milk
Pink	3.5% " " "
Blue	4.0% " " "



THE "PROVED SIRE" METHOD DEMONSTRATED BY THE HEREDISCOPE

Figure 19

Starting with a sire homozygous for fairly high production and with dams with a much lower production, the chart shows the "herediscoped" results of six generations of proved sire breeding. The continued mating of proved sires to the daughters of proved sires has resulted in breeding up the dams from maximum of 8,000 pounds to a maximum of 16,000 pounds. The variability of offspring and the chances of "reversion" to a lower level of milk production are decreased in each generation.

and daughters and dams are tested in so far as possible under the same environmental conditions.

The other photographic chart shows the succession of proved sires that have been used at the Huntley Station in the project of breeding a pure line for high production, but only daughters of the first two sires have completed records at the Huntley Station. The records given for the other sires are the records made in the herds from which these sires were purchased. These records are the basis for their selection for use in the Huntley herd.

In view of these projects that are under way at the Field Stations of the Bureau of Dairy Industry, it is interesting to run through on the herediscope an example of the continued mating, for six generations, of sires possessing a genetic constitution for a hight level of production. This has been done as shown in Figure 19, assuming dominance for the factor determiner for the higher production, of each allelomorphic pair. The first generation mating is between females having an inheritance for a maximum of 8,000 pounds milk and a minimum of 6,000, and homozygous for 3 per cent fat, and a sire that is homozygous for 14,000 pounds milk and 3.5 per cent fat. The result of this mating is assumed for purposes of illustration to represent the average genetic constitution of a group of females with a maximum inheritance for 14,000 pounds, 3.5 per cent milk and a minimum of 6,000 pounds, 3 per cent milk. The second generation sire mated to these females has a genetic constitution for a maximum transmitting ability of 16,000 pounds 4 per cent milk and a minimum of

TABLE III.—Showing Variation in Records Where Ten Successive Trials or Matings Were Used Between Animals of the Same Genetic Constitution as the Animals Possessed in Each Generation in Fig. 19.

FIRST GENERATION

Maximum		*Minimum*	
Milk	*% Fat*	*Milk*	*% Fat*
14000	3.5	8000	3.0
14000	3.5	6000	3.0

SECOND GENERATION

12000	4	8000	3
14000	4	8000	3
14000	3.5	8000	3
14000	3.5	8000	3
14000	4.0	8000	3
16000	3.0	12000	3
14000	3.5	6000	3
14000	4	8000	3.5
14000	4	10000	3.5
14000	3	8000	3

THIRD GENERATION

14000	4	12000	4
16000	4	12000	3.5
14000	4	14000	3.5
14000	4		
16000	4	10000	3.5
16000	4	12000	3.5
14000	4	14000	4.0
14000	4	10000	4.0
14000	3.5	10000	3.0
14000	3.5	14000	3.0

FOURTH GENERATION

Maximum	*Minimum*
16000 4	14000 3.5
18000 4	12000 3.5
14000 3.5	14000 3.5
16000 4.0	12000 4.0
14000 4.0	14000 3.5
16000 4	14000 4.0
16000 4	12000 3.5
16000 4	14000 3.5
14000 3.5	14000 3.5
16000 4	12000 4.0

FIFTH GENERATION

16000	4	14000	3.5
18000	4	14000	3.5
16000	3.5	16000	3.5
16000	3.5	14000	3.5
16000	4	16000	3.5
16000	4	14000	3.5
16000	4	12000	4.0
14000	3.5	12000	3.5
18000	4	12000	3.5
16000	4	12000	3.5

SIXTH GENERATION

16000	4	16000	3.5
14000	4	14000	3.5
16000	4	14000	3.5
18000	3.5	14000	3.5
14000	4	14000	3.5
16000	3.5	14000	3.5
16000	4	16000	3.5
16000	4	14000	3.5
16000	4	14000	3.5
16000	3.5	16000	3.5

12,000 pounds 3.5 per cent. From this mating we get our third generation females with a genetic constitution the maximum of which is the same as that of the second generation females, but the minimum has been raised from 6,000 to 12,000 pounds. To these third generation females we mate a sire having a genetic constitution with a maximum of 16,000 pounds 4 per cent milk and a minimum of 12,000 pounds 3.5 per cent milk. This is the same genetic constitution as the second generation sire excepting for the half per cent increase in per cent fat. The fourth generation females have the same genetic constitution as the third generation females. The fourth generation sire, however, has a genetic constitution with an increase of 2,000 pounds milk in both the maximum and minimum, over that of the third generation sire. The result of this mating shows an increase of 2,000 pounds in the maximum of the genetic constitution of the fifth generation females over that of the fourth, but with the same minimum. The fifth generation sire has the same genetic constitution as the fourth generation sire. The result of this mating is an increase of 2,000 pounds milk in the minimum, bringing it up to 14,000 pounds. The mating of these animals to the sixth proven sire having the same genetic constitution as the fourth and fifth sires, does not change the genetic constitution of the daughters which remains at 16,000 pounds milk for a maximum and 14,000 pounds for a minimum. Thus in five crosses of sires having a genetic constitution for a fairly high level of production the genetic constitution of the herd was increased from a maximum of 8,000 to a maximum of 16,000 and from a minimum of 6,000 to a minimum of 14,000 pounds milk.

This illustration, however, has been carried out with one mating in each generation. We have already shown that where there is some heterozygosis in the genetic constitution for milk producing capacity, such as exists in the genetic constitution of the sires used, there would be considerable variation in the milk producing capacities if there were a number of matings for each generation. To show this I have gone back and made 10 trials for each generation with animals of the same genetic constitution possessed by the animals in each generation in Figure 19. The results are shown in Table III It will be noticed that with each successive generation of proved sire mating the variation decreases.

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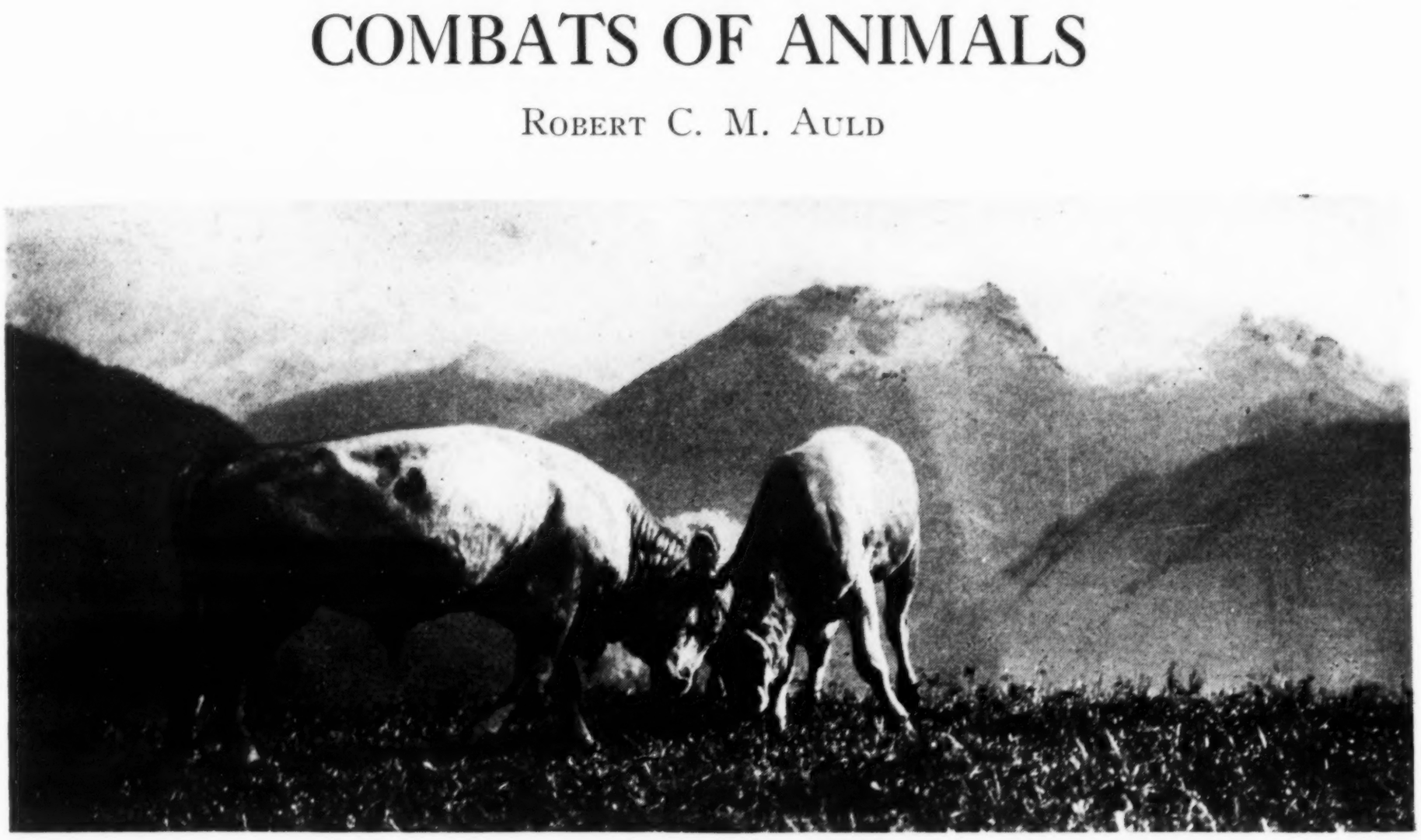
COMBATS OF ANIMALS

ROBERT C. M. AULD



AN ALPINE BULL FIGHT

Figure 20

An unstaged, but nevertheless picturesque bull fight in the Saanen valley, Bernese Oberland, Switzerland.

THE tactics of animals in combat is a subject of great interest to students of animal behavior and to breeders of animals, and might well engage the literary skill and investigative spirit of a Fabre.

The writer has been quite restricted, however, in his opportunities of observation—his field extending merely to some of the domestic animals. In the following notes gathered from various sources he has attempted to describe certain features of unusual combats that appeared to be of sufficient importance to be placed on record.

He has, in his own experience, been able to pay closest attention to the combats of hornless cattle, and he is fully convinced that "the polled can take full care of themselves" in any encounter with rival bovines, and that they are quite able to overcome their horned opponents. It is curious that no descriptions of a polled fight appears to have been given by observers of such animal combats.

The fight is a simple affair with two polled animals; there are no horns in the way and the animals come into direct contact, skull to skull at once with a loud thump. This, of course, after the belligerent bellowing and tearing up of the turf and other manifestations of defiance. The bulls, as they are generally the ones that indulge in this taurine pastime, having thus come together skull to skull—it becomes not a matter of skull butting, but of straight pushing. They spread their legs apart and dig their hoofs into the ground to get a better purchase, their heads lowered and backs raised. The strain is seen in the bulging muscles and the crouching position. The bulls seem immovable, all that is visible is the muscle strain and quiver of the hind quarters. Weight or superior muscle-power tell and suddenly one gives way. He is thrust aside and the victor gives him a terrible punch on the fore ribs that often turns the conquered over on his body. The vanquished bull grunts and is forced away and yields quickly and gracefully—for there is apparently no hard feeling

harbored. The superiority of the stronger is acknowledged and the victor receives the constant homage of the conquered.

With horned bulls the encounter is rather more complicated, because of the possession of "weapons".

In an interview with the Des Moines Register, Fred Dressler, Manden, Nev., attending "Polled Hereford Week" sale, is quoted as saying "Everyone told me that the horned bulls would soon kill the polled bulls or 'muleys', as we call them, when I first turned them loose on the range. We found, however, that the polled bulls could lick the horned fellows every time. The polled bull puts his head between the front legs of his opponent, tosses him in the air, butts him on the flank or on the rump and the fight is all over. We have both horned and polled bulls, but the 'muleys' are 'bosses' of the herd."

What we may regard as the classic description of such a combat is that furnished by "Victor", in Dr. James Anderson's famous *Recreations in Agriculture*, p. 406, vol. V., 1802:

As we proceeded in our walk my attention was arrested by a phenomenon that appeared to me to be of very awful and interesting charcter: so that I was delayed to contemplate it with fixed attention.

Two herds of cattle, consisting of twenty to thirty head on each side, each pasturing on their own native fields, had by chance approached so near as to be within the ken of each other. No sooner did the one herd observe the other, than the bulls on each side advanced before the rest, growling, as it might be called, and sending forth a deep and hollow roar of mutual defiance. They advanced slowly with their heads low in a menacing manner. As they approached nearer to each other, their roar became more loud and their attitude more menacing; and, while they bellowed with a deep murmur; they tore up the earth with their forefeet, and tossed it high in the air behind them; sometimes also tearing it up with one of their horns. The whole herd on each side imitated the same actions, and the mountains re-echoed with the deep and loud bellowing, so as to excite a sensation of horror the most tremendous that I had ever experienced.

This sensation was at the present heightened by the dark gloomy appearance of the clouds, which settled, as it were, above them, fragments of sod, tossed into the air on all sides exhibited, in falling, the appearance of a shower of a singular sort. The elements themselves seemed to be at war. The roar was loud and various. They all rushed into battle, however, breathing defiance to each other; and the universal destruction of the whole seemed to be immediate.

The moment they engaged all bellowing was at an end. They were too seriously engaged to think of menacing sounds. The struggle was long: the exertions of each individual were strenuous; and carried on with a high degree of obstinacy. When any one at last was forced to give way to the superior power of his opponent, it seemed at that time impossible for the weakest to avoid destruction; for the most powerful, after having pushed back his adversary, never failed to attempt to gore him in the side with his horns with all his force; but the danger was evaded by the weaker animal instantly giving up the combat, and receding as nimbly as possible from the thrust. When once conquered, he immediately showed his inferiority to the conqueror by the most submissive obedience, with which the conqueror seemed to be entirely satisfied and from that moment all animosity between these two was at an end; for, whenever they met the one no sooner claimed superiority then the other readily allowed it. The beast, however, who was conquered by one individual did not on that account deem it necessary to yield obedience to others of the same party. He attacked in his turn another whenever he considered him his inferior; and if the superiority was not aknowledged on one side, another battle ensued. The combat, in short, was solely between individual and individual; and although the two bulls arrayed themselves at first on opposite sides, as if with a view to protect each other, and try their united strength, it was soon very evident, that no idea of that kind ever took place. Each herd had previously settled the authority among themselves; and every individual among them had already ascertained before that time the station that belonged to him; and he knew as well those who were under his authority and above it, as the higher and inferior orders in a regiment do their respective ranks, and exacted and obtained the deference due them, and performed the obeisance due from him to others, with the same alacrity. The aim of distinction among men is to add greater force to their united efforts; to make the party in short more powerful, without aiming at individual superiority. Individual authority alone is all that the animals aim at; and, this once attained every cause of contention is at an end, and the war entirely finished. In the space of half an hour the war which seemed to

A COW FIGHT IN THE VALAIS, SWITZERLAND
Figure 21

There are annual events, to determine the "Queen" of the herd. Her supremacy is said to be unquestioned until the next contest.

threaten destruction to the whole of the parties engaged was entirely at an end; and all the individuals were as quiet and peaceful as they ever could be, and associated together in harmony and repose. Nothing can be more natural than the whole procedure, when it is cooly reflected upon; yet, until it was forced upon my attention by the singular rencountre that I have specified, I frankly own that this particular herd never attracted my notice in the smallest degree. I was therefore happy in having an opportunity of observing this singular trait in the natural-history of this very useful domestic animal.

The rather disappoinnting feature of this description is that the writer does not describe the immediate force of the come-together, or contact of the heads of the horned bulls—to what ex tent their horns interfered or were obstructive to the skulls being used as battering rams against each other. Being in Scotland we might assume that the bulls would be of the wide-horned, West Highland breed.

But the description reminds us of that which must have occurred in the more famous encounter of the bulls in the Irish epic, "The Tain Bo", the story of which has to be read in full to be enjoyed.

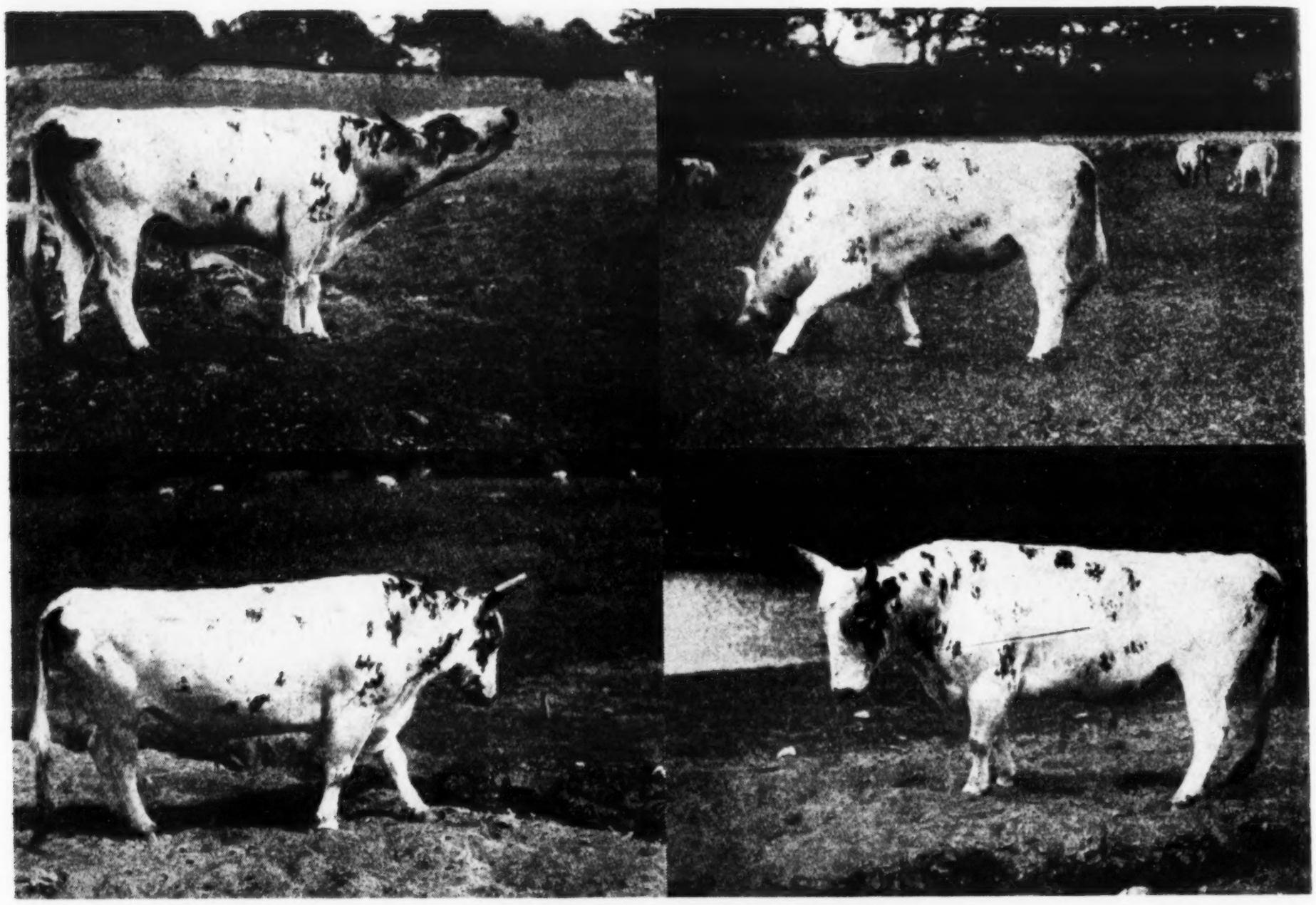
Cow Fights In the Alps

Such combats are generally supposed to be solely between the bulls of the herd. But in the Alps, the inherited instinct of the herd fight has become an organized event of the herdsman's life—and that, too, of the herd itself. In the Canton of Valais, Switzerland, these combats take place every year in the month of April, and they are designed to decide which matron shall become Queen of the Alps for the season. Great importance is attached to these duels.

It is after the snow has melted on the lower slopes of the mountains that the herds are shifted from their winter quarters to their summer grazings and mount the sides of the Alps to feed on the rich provision of nature in these heights.

The owner of the herd chooses two or three young cows to fight the last year's queen to decide which shall have the place of Queen for the coming season. There is a reason for this function. By thus determining which animal of the herd is the Queen, she, as the dominant animal, exacts obedience from the other members of the herd and all free fights in the high Alps that might lead to the death or disablement of valuable members of the herd is avoided.

A sunny Sunday is chosen for what



PREPARING FOR BATTLE

Figure 22

"Under the many displays of temper on the part of animals that have come under my notice that of a certain Ayrshire bull has left the deepest impression on my mind. When at large with other cattle in the fields he challenged all who came near him, always posing in the well known attitude assumed by cattle in the angry mood. As he was always anxious to oblige a stranger by going through his paces, I felt unusually anxious to have photographs of him in some of his striking positions. Here was an animal ready to fight anyone at the drop of the hat. "Never trust a bull" was the warning, and especially in regard to this one as in his case there would be no method in his madness when aroused, which might be done by the most trivial incident. But fortified and taking up strategic positions some excellent snaps were secured of this fighting taurine."—The late Charles Reed in the *Breeders' Gazette.*

is an event in the community; all the people of the surrounding villages flock to the scene and make of the day a holiday. Betting is even indulged in as to the result of the contests.

And the cows seem thoroughly to understand what is expected of them. They become excited; the Queen is ready to meet all comers and defend her right to reign another season. She being recognized as leader of the herd, it frequently happens that the young candidates selected to contest her right, when confronted with their task, turn in flight, amid the laughter of the spectators. But another may enter the ring and she may make a dash for the Queen, whose blazing eyes are fitted to confound all challengers. But once a collision occurs the fight is conducted with all the well-known bovine tactics. Heads collide and horns seem to become locked. The struggle may continue for half an hour. The object of the combatants is for one to push the other off the field or force it to give up the fight by retreating, helped by a final shove or thrust from the victor.

The defeated cow is a pitiful object, sorrowful to witness, as she feels her degradation apparently keenly. She will refuse to eat for days, she will mourn and even cease to yield her milk for some time. But the other, subject,

AS ONE ELEPHANT TO ANOTHER
Figure 23

A fight arranged for the amusement of the guests of the Gaekwar of Baroda on the fiftieth anniversary of his accession to the throne. From *New York Times.*

cows follow their new Queen, grazing behind or around her as an honor guard. Thus the herdsman's work is made easy, for where the Queen is there the others always are. Her majesty fully realizes her proud position and is always ready to fight for her herd and protect it aganist outside aggression, especially dogs; or by driving away strange cows that attempt to invade or trespass upon her herd's pasture.

The accompanying photographs show two contests—one between cows in the Valais; the other between two bulls of the Sannen Valley in the Bernese Oberland.

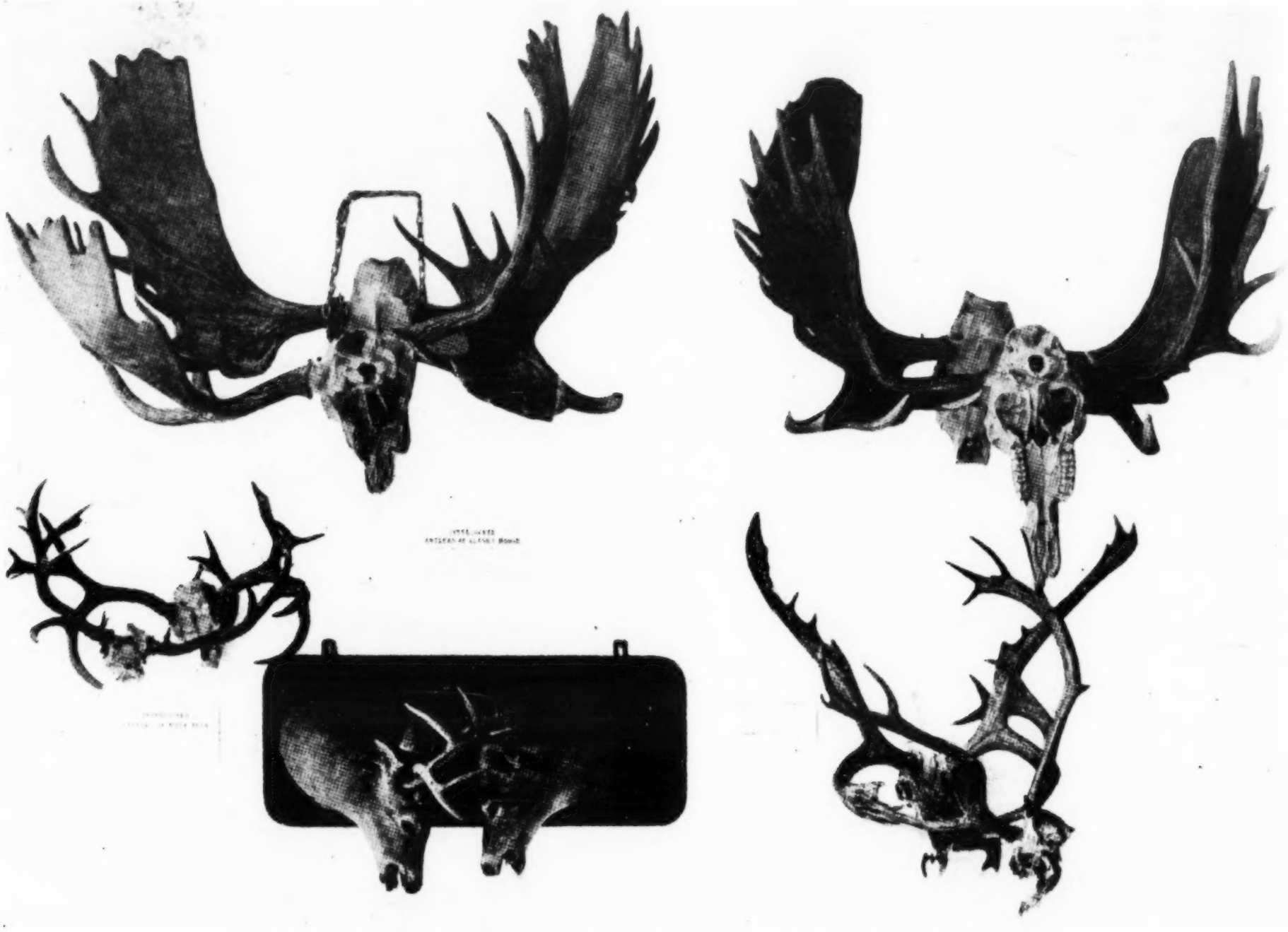
In Southern France is also a popular form of bull fight in which the toreador is frequently injured but the bull never. An angry bull is turned loose in the arena provided. A small red cockade is fastened tight to his brow on a string between the horns. Any man, confident enough and skillful enough to try conclusions with the bull by snatching the cockade and escaping with his life gains renown and prize money galore.

On the western ranges numerous occasions must occur when these fights can be witnessed—but again we have never been able to see any pictures of hornless bulls in combat.

Of combats of bulls with other animals, those with man are of peculiar interest. There are stories galore of Herculeses encountering strong bulls, seizing them by the horns, twisting their necks and so overcoming them.

On the American range there has developed the desire to do stunts with uncouth, obstreperous animals of the bovine race. Anyone, as has been said, "can throw the bull", which is an airy figure of speech not of flesh and bone and sinew. But the cowpuncher deems it proper that he should be able to throw a real bull and makes frequent essays to that end.

But it is in Spain that the acme contest between the brutal propensities of the bull trained to gory combat and the quick wit and agility of the human contestant is to be seen, in these Corridas where the battles are "staged". These bulls are of a special breed, and as particular pains is taken to breed them for this particular aptitude as is taken by the most successful herdsman in Britain. If any reason might be demanded for these bull-and-man contests of Spain, Henry de Montherlant's "The Bullfighters" might be recognized as expounding its gospel. Here we realize that the fight seems to symbolize all that is regarded as chivalric in



COMBAT SERIES OF INTERLOCKED ANTLERS
Figure 24
Alaskan Moose, American Moose, Mule Deer, Virginia Deer and Newfoundland Caribou.

the Spanish breast, certainly it needs something other than a Quixote to face the frightful odds that seem swung against the human opponent of the mysticised bull, the offensive actor in the Mithraic cult of the Corrida.

In the Bronx Zoological Park is the famous Heads and Horns Museum, the particular pride of Director William T. Hornaday, in which a splendid exhibition of horns is housed in a magnificently ample fashion. One of the exhibits of interest is that of the "Combat series of interlocked antlers" in which Alaskan moose, American moose, Mule deer, Virginian deer and Newfoundland deer provide remarkable specimens. These show that couples of these species had got into fights, in which horns becoming locked, the bearers died together of exhaustion.

It will be seen that horns of the character found in these species are a tremendous handicap, as we might say, to the happiness of the animal—even in peace as in war. The muley deer is much more prosperous in this respect and as shown in the representation of a fight between two hummel stags in the article "Polled and Horned Cattle"* the combat seems based on comparatively equable conditions, but the force of the hoof, the stamp of the foot, brings forth all the fighting instinct and makes the suppression of the weaker contestant easy.

*Journal of Heredity 18:309-321. 1927.